The Man In The Chair:
Cornerstone Of Global Battlespace Dominance

A Research Paper
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Disclaimer

2025 is a study designed to comply with a directive from the chief of staff of the Air Force to examine the concepts, capabilities, and technologies the United States will require to remain the dominant air and space force in the future. Presented on 17 June 1996, this report was produced in the Department of Defense school environment of academic freedom and in the interest of advancing concepts related to national defense. The views expressed in this report are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the United States government.

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Preface

In December 1994, Gen Ronald R. Fogleman, Air Force chief of staff, initiated ***Air Force 2025***—a study to identify air and space power requirements 30 years in the future. To support the effort, General Fogleman tasked Air University to generate white papers that would seed the Air Staff and major air commands with new ideas and concepts for the future. Air University responded by creating more than 30 teams to focus on distinct areas of mission emphasis. This white paper embodies the research conducted by one of those teams—the team responsible for conceptualizing what "Space Surveillance and Reconnaissance Fusion" means in the year 2025.

Our vision of surveillance and reconnaissance fusion in 2025 clearly identifies an intelligence architecture with human-like characteristics. It will simultaneously sense and evaluate the earth in much the same way you remain aware of your day-to-day surroundings. This vision is so central to assimilating the paper's underlying details that our architecture bears as its title the acronym MITCH (derived from the "Man In The CHair"). We hope this technique of personification will anchor readers to the human analogy drawn throughout the paper.

The concept and technologies behind MITCH merit further development. Feedback from top-level professionals serving as ***2025*** advisors and assessors strongly supports this assertion. Maj Gen Garrison Rapmund, USA, Retired, for example, believes the vision of MITCH is an essential tool for our decision makers in Washington. He believes our vision provides a framework for understanding how the stream of new information technologies can be applied. The ***2025*** advisors noted that MITCH stood out as one of "the nuggets" in the Air University effort. Gen Bernard Schriever, USAF, Retired, strongly concurred and recommended forwarding MITCH to the chief of staff of the Air Force as one of ***2025***'s top concepts. *The message from these senior leaders is clear: the work in this paper must not be laid to rest on a dusty shelf. Let the real experts take it and run with it.*

That said, we acknowledge the assistance and guidance we were given during the course of this study. First mention must go to those who guided the efforts across the Air War and Air Command and Staff Colleges. The leadership of Col Richard Szafranski, Col (PhD) Joseph Engelbrecht, Jr., Col Michael Kozak, and their respective staffs served as catalysts to all ***2025*** papers. Second, reviewer comments from the Air Force's Scientific Advisory Board, ***2025*** advisors, and the Air Force Institute of Technology played key roles in our ability to add finishing touches to our concept. Third, this paper drew strength from work previously advanced in Air University's SPACECAST 2020 study and the Scientific Advisory Board's recently completed *New World Vistas: Air and Space Power for the 21st Century*. These studies offered us a point of departure from which to introduce the Air Force's next leap toward leveraging the "Information Age." Finally, we acknowledge the efforts of Lt Col (PhD) T. S. Kelso, CDR Homer Coffman, and Ms Marlene Barger. These individuals worked tirelessly to make it easier for students to meet both ***2025*** and Air Command and Staff College requirements.

Executive Summary

A general should possess a perfect knowledge of where he is carrying on a war.

—Niccolo di Bernardo Machiavelli

Knowledge of the battlefield has always been a matter of life or death for the warrior. By 2025, the importance of this concept will be magnified—growing weapon lethality and ever-tightening decision cycles will demand near-real-time and continuous battlefield awareness. In short, possessing knowledge will not simply determine who will live but who will win. This paper provides a vision for the future, *describing a concept and a system that provides the United States with the cornerstone for unrivaled comprehension of the 2025 battlespace by giving the <u>right</u> decision makers the <u>right</u> information at the <u>right</u> time.*

The proposed system is both evolutionary and revolutionary. It is evolutionary in that it capitalizes on emerging satellite technologies to more fully exploit the "high ground" of space for surveillance and reconnaissance; continuous global awareness is the result. It is revolutionary in what happens as space collectors pipe their data of the world to a terrestrial "brain" that fuses it with data from all other sources. This "brain" leaps beyond data, creating what is really required by decision makers—information, and if possible, knowledge. Logical patterns are established. Additional sensor collection is autonomously ordered to improve information quality. Conclusions are drawn. In effect, the system functions much as the human does—subconsciously aware of the general environment, focused on stimuli of importance, and continuously making sense of it all. That is the revolution, and information dominance flows from it.

In addition to developing a vision, this paper proposes the capabilities required to bring that vision into reality—truly *global* surveillance, responsive high-resolution reconnaissance, around-the-clock access, fusion of data into information, and answers for decision makers at the *right place and time*. These capabilities are brought together in a human analogy, the "Man in the Chair." This analogy provides a conceptual understanding for a new system that will serve as the cornerstone of global battlespace

dominance. The paper identifies the specific technologies required to build such a system. What emerges is a powerful mix of small satellite, high-capacity communication, processing, storage, and artificial intelligence technologies. The system is called MITCH, "Man In The CHair."

On their own, these new technologies are not enough to "bring MITCH to life." How decision makers interact with the system is just as important as the system itself. Recognizing this, the authors discuss the concept of operations. This concept exploits links across every medium to give users and decision makers the product they ask for. This concept of operations also allows MITCH to alert users with information that deserves immediate attention. Both approaches are captured in vignettes that demonstrate MITCH's usefulness in both combat and peacetime operations.

The road MITCH must travel to 2025 is a difficult one. The last chapter highlights three critical aspects of that road. First, commercial initiatives must be complemented by government developments in selected areas. Second, users and decision makers must come to trust MITCH as an integral part of their decision processes. Third, an acquisition strategy must be pursued that embraces these ideas. Success in these three areas will underpin the ability to bring MITCH on line by 2025.

MITCH. The "Man In The CHair." A system designed, acquired, and operated as the cornerstone for unrivaled comprehension of the global battlespace. In the dynamic and uncertain world of 2025, the security of the United States of America rests on the aggressive pursuit of the vision MITCH offers.

Chapter 1

Introduction

The doctrine of war is to follow the enemy situation in order to decide in battle.

—Sun Tzu
The Art of War

> The American colonel searched the terrain slipping under the wings of his multirole fighter. It was rugged country, pocked here and there with scars of war. The day's mission was simple: seek out and destroy a small Iranian armored force believed to be infiltrating the Coalition's rear area. "*Believed* to be infiltrating." He grimaced at the thought, acknowledging the uncertainty plaguing the American's first high-intensity combat since the Gulf War in 1991. The Iranians had succeeded in strategically surprising the world with their occupation of the oil-rich Persian Gulf region in 2013. A year later, their fluid, small-unit operations continued to hamper the coalition's efforts to free the region. The colonel squinted. He knew the coalition would eventually prevail, but regretted the losses slowly mounting with each passing day. His eyes cross checked his wingman and then headed back to the ground. "It didn't have to be like this," he reflected. Desert Storm, a conflict where he saw 23 combat sorties as a brand new captain, "footstomped" the critical importance of knowing where your enemy was—in time to do something about it. Everybody had seen it, but the point was dulled somewhere in the drawdowns, budgets, and forecasts of low-tech wars. The military application of commercial developments could have been so much more. The colonel glanced at his fuel gauge. Bingo—time to head home. In the end, he would never know that the infiltrating armored force had diverted away from the area he so meticulously combed. That was information still adrift in the US intelligence community's sea of data. He would soon discover, however, something completely missed by US sources. The Iranians had deployed advanced SAM batteries into the region. In fact, they were the last thing he would ever see.[1]

Reduced to its simplest elements, war is about killing or being killed. It is about destroying or being destroyed. In Sun Tzu's wisdom, war's endgame is deciding battle on terms favorable to friendly forces. But if "everything in war is simple," then why does Clausewitz go on to say that "the simplest thing is difficult?"[2] The above vignette of an American warrior in the future suggests an answer. To kill or destroy, one must know where the targets are. To survive, one must know where the threats are. In short, one must

follow the enemy situation—historically, one of war's and the world's most difficult challenges. This paper addresses that challenge and how it can be met in the year 2025.

It seems certain that following the enemy situation will be more difficult to master in 2025. Martin van Creveld predicts the world will be embroiled in numerous regional, low-intensity conflicts.[3] Perhaps China, as suggested in the ***2025 King Kahn*** alternate future, will challenge the United States (US) as the world's superpower.[4] Whatever the situation, it will involve American national interests. Supporting this, Alvin and Heidi Toffler note that the number of agreements and treaties between the US and other countries is growing exponentially, reflecting an "exploding" American interdependency around the world.[5] In this environment, almost every location on the globe becomes a potential battlespace—economic, political, or military. Numerous nations, as well as many organizations, become potential adversaries.

How will the US tell who its enemies are? And for that matter, how will the US tell who its friends are? What events will affect the interests of the country? Which will not? In 2025, Sun Tzu's challenge takes on a new perspective. In order to decide in battle—no matter what form it may take—the US must be able to *follow the situation of the world*—the global battlespace. The survival and continued success of the country may well depend on it.

Following this global situation, this global battlespace will be not be easy. It demands that tough questions be asked and answered. What are the basic abilities, the core competencies, the US *must* possess? Next, what capabilities are required to bring these core competencies to reality? Only with a detailed and thorough understanding of these issues will the US possess the foundation needed to meet the challenge of 2025—*to follow the situation of the world.*

This paper takes precisely the approach suggested above. It *describes a concept and a system called the "Man In The CHair," or MITCH, that provides the United States with a cornerstone for unrivaled comprehension of the 2025 battlespace by giving the right decision makers, the right information, at the right time.*[6] In following this thesis, it should be clearly understood that MITCH's purpose is not to decide on courses of action—that is for human decision makers or automated targeting systems to do. Instead, MITCH gives those decision makers information about the global situation that is unmatched in quality and

availability. MITCH is the answer to Sun Tzu's age-old challenge "to follow the enemy situation in order to decide in battle."[7]

Notes

[1] This is a plausible scenario based on background research by the ***2025*** Alternate Futures team, part of an Air Force chief of staff directed study conducted at Air University during the 1996 academic year. This study hypothesized a conflict with Iran by 2015.

[2] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, N. J.: Princeton University Press, 1976), 119.

[3] Martin van Creveld, *The Transformation of War* (New York: The Free Press, 1991), 194.

[4] One possible alternative for the world in 2025 was a future scenario titled *King Kahn*. This plausible scenario was developed by the ***2025*** Alternate Futures team. It is one of six scenarios developed by the team.

[5] Alvin and Heidi Toffler, *War and Anti-War* (New York: Warner Books Inc., 1993), 293.

[6] The concept and the system presented in this paper use the term man in a generic sense. This was done to provide the reader with a clear and distinctive vision that would bind together the various concepts and technologies presented. Using the concept of the "Man in the Chair," and the system name derived from it, MITCH, allows a personification of the system which is needed to clearly convey the authors' concepts.

[7] Sun Tzu, *The Art of War*, ed. and trans. Samuel B. Griffith (London: Oxford University Press, 1963), 140.

Chapter 2

Required Capability

Core Competencies: The First Step

Following the global situation and using it to dominate the global battlespace require two things—the ability to see what is happening at all times and the ability to get the right information to the right decision maker at the right time. It requires the core competencies of global awareness and information dominance. This first step must begin with a clear understanding of what these two competencies are—and what they are not—and examine why they will be important in 2025.

Global Awareness

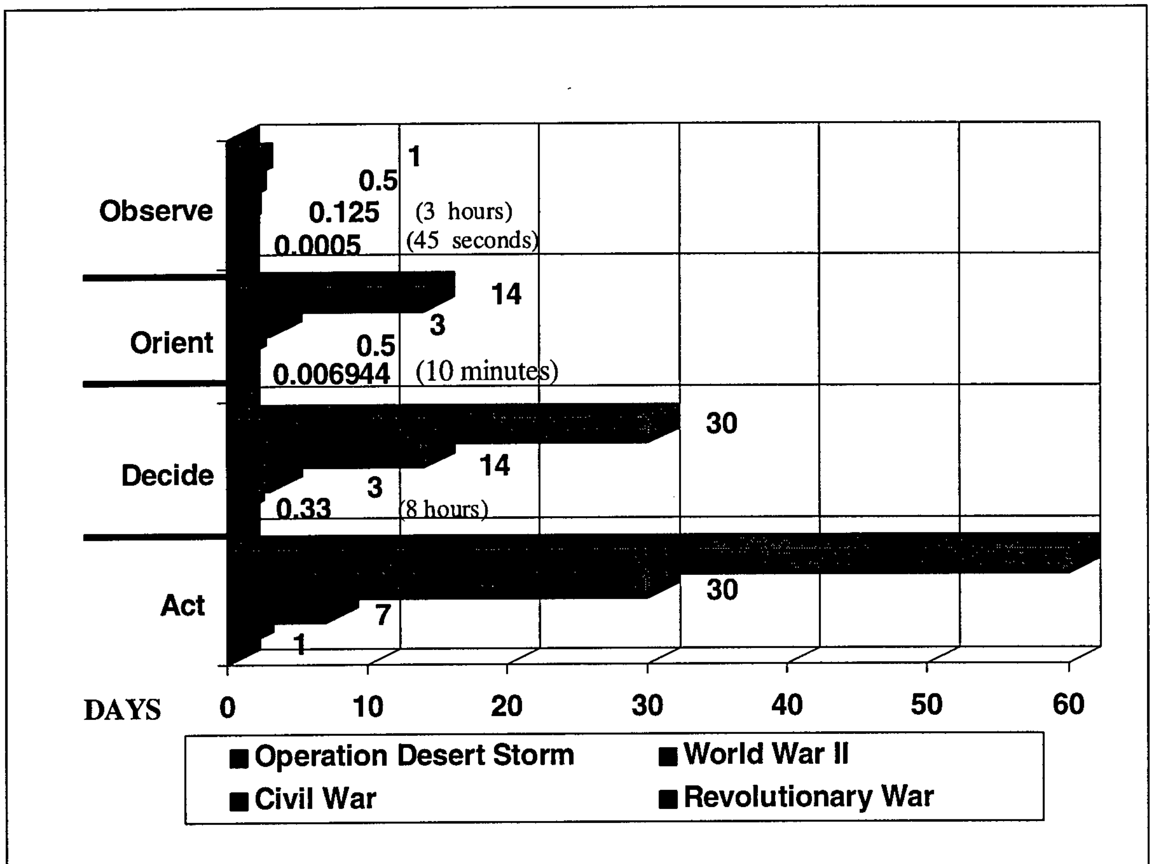
Global awareness is the ability to reliably, accurately, and continuously collect information on the situation, enemy or friendly, anywhere in the world. It is the mechanism that pinpoints targets and threats. Global awareness is a matter of degree and not an absolute—*no approach to it will ever achieve total omnipresence*. Instead, global awareness implies the ability to pull as much useful information from a region as the laws of physics permit. The degree to which future systems succeed in that endeavor will be determined, in large part, by the sensors and intelligence techniques of that day.

Information Dominance

This second core competency is the ability to intelligently route the right information to the right decision maker at the right time. This mechanism allows the decision maker to decide in battle. Again, success in this competency is relative and not absolute. *No approach will ever permit omniscience*. Instead, information dominance occurs when US decision makers possess the information required to make decisions faster and better than any enemy.

The Importance of Global Awareness and Information Dominance

Certain trends leading to the year 2025 make global awareness and information dominance critical to successfully following the global situation. First, rapid technological growth will almost certainly threaten United States (US) military forces with increasingly capable opponents. These opponents will possess weapons that are more lethal. They will develop surveillance and targeting architectures that make them better at finding and targeting American forces. In effect, combat will become less forgiving to the force fired upon first. Where the penalty of previous wars has been measured in terms of men lost, the penalty in 2025 could be measured in units lost. The second trend driving global awareness and information dominance is the shrinking time available to decision makers as they strive to act first. Said another way, John Boyd's proposed "OODA loop," (Observe, Orient, Decide, and Act) is ever tightening.[1] Figure 2-1 shows how the OODA loop of American forces has dramatically collapsed since the Revolutionary War.



Source: Data from ACSC Technology Division and War/Theater Level Studies Department, *The O-O-D-A Loop Toolbook*, Maxwell AFB, Ala., 1995.

Figure 2-1. Shrinking Decision Cycles/OODA Loops.

Extrapolating this historical characteristic out to 2025 leads one to anticipate a near-real-time decision cycle where observations are received in near real time; orientation is continuous; decisions are arrived at immediately; and actions take place in seconds. Indeed, by 2025, the OODA loop may well be an *OODA point*—an environment for which today's military is not equipped. So what is to be done by 2025? What capabilities ensure the global awareness and information dominance required to deal with the future's lethality and real-time tempo? Answering these questions requires a look at the past.

The Road to Required Capabilities

The basic concepts underlying global awareness and information dominance are not new. For centuries, decision makers and military forces have sought victory over their adversaries by gaining a better "view" of the situation and obtaining better information from which to base decisions; this will not change in

the future. In that regard, this section briefly looks at past, present, and near-term efforts to provide the right intelligence information to the right decision makers. Within that framework, four specific areas are addressed including (1) the evaluation of Gulf War information systems by senior decision makers, (2) the importance of system integration and fusion of data, (3) the value of space as the new high ground, and (4) how advances in systems since the Gulf War continue to fall short of what is required for the future.

A Brief Look into the Past

The various services have sought to develop new and better information systems—each seeking to provide the right product, to the right decision maker, at the right time. The Gulf War was the first real test of what the military had spent many years and dollars to develop. Maj Gen James Clapper, USAF, former director, Defense Intelligence Agency and Air Force Intelligence, stated that the Gulf War "served as a crucible for systems that collect, analyze, fuse, and disseminate intelligence."[2] The results of that trial were captured in the testimony of Gen H. Norman Schwarzkopf, Commander in Chief Central Command, before the Senate and House Armed Services Committees. In that testimony, he conveyed he did not always have the information he needed and recommended the intelligence community immediately begin developing systems "capable of delivering a real-time product to [the] theater commander when he requests [it]."[3]

The Need for System Integration and Fusion

General Schwarzkopf's remarks prompt a closer examination of the war often praised as a prime example of a successful intelligence operation.[4] What emerges is evidence that the nation's intelligence systems lacked effective integration. War fighters were forced to use a number of different intelligence-gathering systems, each providing a separate image or description of the battlespace. As a result, Desert Storm operations required extensive human effort to merge the different system products. This requirement created information overload and often denied decision makers the intelligence information they needed at key junctures. A critical missing element was "fusion"—the combining of "multisource data into intelligence necessary for decision making" without degrading timeliness or creating information overload.[5] Without question, detailed information was available, but it was not in the right hands at the right time—constraining

information dominance. To complicate matters, limited numbers of sensors, both spaceborne and airborne, provided only periodic, incomplete coverage of the battlespace—preventing global awareness.

The Importance of the High Ground

Notwithstanding the shortcomings just discussed, Operation Desert Storm has been christened the "first space war" and did provide hints of future required capabilities.[6] Indeed, the Gulf War reiterated the timeless advantage of the high ground in "viewing" the enemy. According to Sir Peter Anson and Dennis Cummings in an article published shortly after the war, "military experts agree that satellites helped to win the political battle, sustained command and control, shortened the war, and saved lives."[7] Space became the new "high ground" and took its place as the foundation of global awareness. This is supported by the words of Gen Merrill McPeak, then USAF chief of staff: "Space is fast becoming the center piece of our strategic leverage. I'm convinced that tomorrow we will judge a nation's power by its relative position in space."[8] American space systems confirmed how the words of Tao Te Ching still apply today:

> Distant ridges, far away clouds . . . All events come from a distance. With a high vantage point, foretelling the future is elementary.[9]

Where Is the United States Headed?

American attempts to take advantage of the new high ground and provide the right information to the right decision maker seem nothing short of revolutionary. On the surface, it would seem every aspect of intelligence gathering, processing, and dissemination has been anticipated and achieved. Appendix A provides a short description of eight current and future systems aimed at tying together various surveillance, reconnaissance, intelligence, and information assets. Yes, access to and quality of information for decision makers and war fighters will improve, but it is not enough for the future. The systems listed, along with others that are envisioned, still present two major problems. First, the national command authority, combatant commanders, and weapon system operators will still be inundated by information from multiple systems providing nonfused products. It seems the United States (US) is slow to grasp the limitations of overlaying one category of information from one system over another category of information from another.[10]

Second, the "view" of the world will still not be continuous. Both problems must be addressed in the future. American decision makers must be able to make the right decisions and do so in seconds—in essence, "points in time." What exists now and what is on the drawing board for the future will not provide the global awareness and information dominance needed to follow the global situation and dominate in battle.

What Capabilities *Are* Needed?

The right product to the right decision maker at the right time. Decisions in points in time. A global battlespace. Friends? Adversaries? No one can predict with certainty what the future will hold for the US. But whatever the future brings, the message is clear. The US must be able to follow the situation of the world—the global battlespace. This ability requires these critical capabilities:

- surveillance to "paint" a global picture with multiple sensor types;
- reconnaissance to provide high-resolution "zoom" in areas of interest;
- persistent, continuous access to the entire globe;
- fusion—the combination of data from various sources into intelligence information needed for decision making—without degrading timeliness or creating information overload; and
- single point access to required/relevant information for a multitude of users.

Capabilities Defined

Surveillance. Reconnaissance. Persistent global access. Fusion of collected data. Single-point access for users. What do these terms and concepts really mean relative to 2025?

Surveillance

Imagine 2025. The rate at which international "hot spots" emerge accelerates with the world's shift to greater interdependency. Mainstream weapons of mass destruction, rapidly deploying forces, and the ever-valuable information edge raise the risks of conflict. To survive, the US must instantly identify all hot spots and quickly amass a wide spectrum of relevant information. In other words, Americans must possess global surveillance through multiple sources.

Global surveillance requires only awareness, not complete knowledge. Drawing back to a definition of surveillance, it is the ability to detect important changes in situations that would remain uninteresting if the status quo were to persist. Since changes across the globe come in many forms, different collection sources must work together to maintain this global awareness. Candidate sources include tried-and-true sensors found today. They include humans in the field. In 2025, they will no doubt include sensors yet only imagined. The point is, where change signatures are left for sensors, surveillance assets must continually monitor those signatures—everywhere.

Reconnaissance

Simply detecting change in the global environment is not enough—today or in 2025. Instead, when change is noted by surveillance assets, decision makers want to know more. Reconnaissance focuses high-resolution collection assets to provide decision makers with a "zoom" look at the region of interest. Like surveillance, reconnaissance is strengthened when different collection sources work together to "paint" a complete "picture" of the situation at hand. In addition, since surveillance may note changes anywhere in the world, reconnaissance assets must also have global access.

Persistent Access

The first two required capabilities mandate that multisource surveillance and reconnaissance systems have global access to any part of the world. The next required capability mandates global access to any region at *all times*. In short, surveillance and reconnaissance must be persistent. A large part of this persistence stems from the mix of collection assets employed. An all-weather, day-night mix is more persistent than a daylight only system. A "behind closed doors" capability (e.g., human intelligence) strengthens persistence further. Absolute persistence is only achieved, of course, if the proper mix of assets has continuous line-of-sight access to the targeted points of interest.

For many surveillance and reconnaissance collectors, line of sight can be assured by the "high ground"—an age-old pursuit of the warrior. Medieval times found scouts climbing the highest hill to observe enemy positions. In colonial times, lookouts, perched atop the masts of their man of wars, sought to locate

the opposing navies. In more modern times, aerial observers flew small aircraft behind enemy lines to identify vital targets. In all these cases, the "high ground" multiplied the effectiveness of combat operations. This remains true today and will remain true in 2025. Any system designed to continually "follow the enemy's situation"[11] will exploit the "high ground" of space.

Fusion

Fusion is the act of bringing together the wealth of data from persistent surveillance and reconnaissance. As defined earlier, fusion is the combining of "multisource data into intelligence necessary for decision making" without degrading timeliness or creating information overload.[12] The core concept of fusion is the combination of *multisource data* into an *integrated information product.* This means that a single, integrated, analyzed "intelligence picture" is constructed from data supplied by various sensors and other sources. The quality and accuracy of the intelligence picture synergistically improves as data from additional sources is included.

Another important concept in the definition is that fusion must occur without degrading timeliness or creating information overload. In other words, when a user needs intelligence information, it is there—in a form that is clear, concise, and not overwhelming.

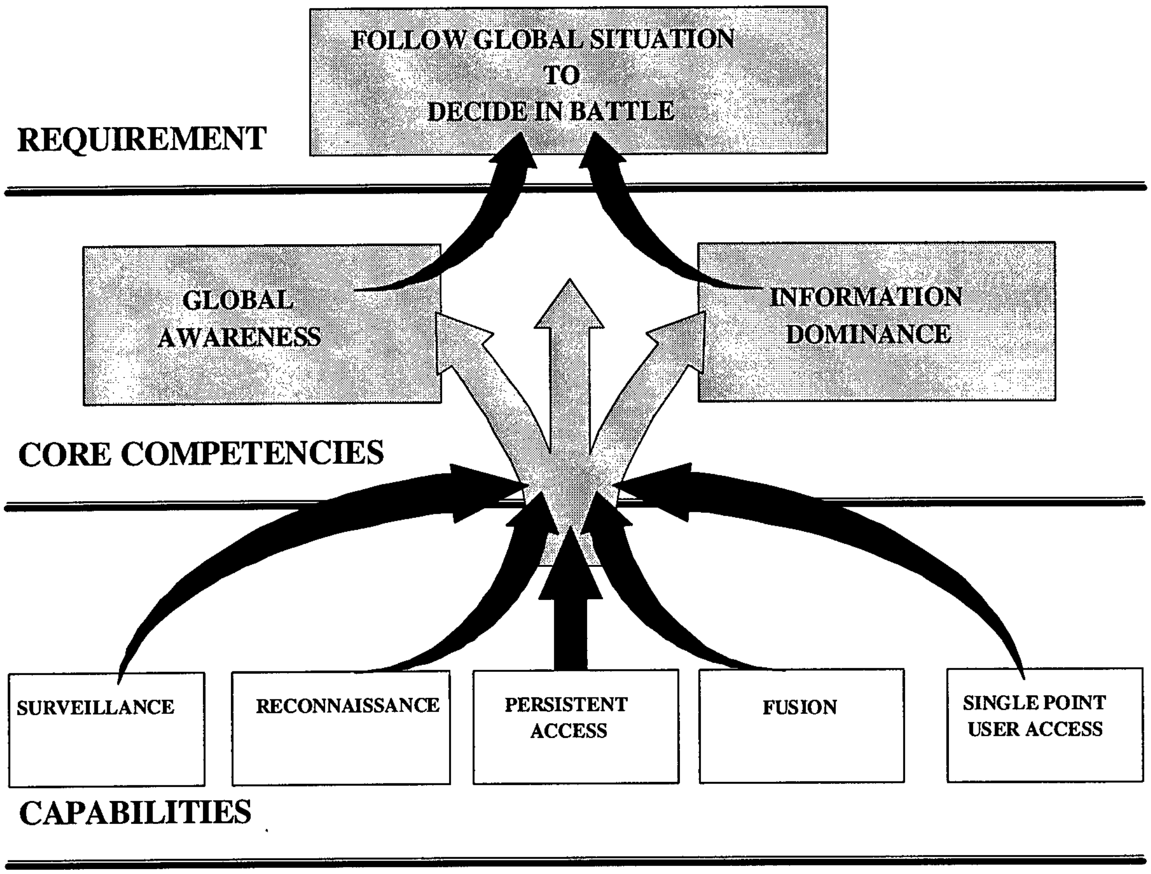
Single Point Access to Relevant Information

Very simply, all users must get the information they need from a single system. This is true whether the decision maker is at the strategic, operational, or tactical level.

The Cornerstone of Global Battlespace Dominance

The five capabilities described above form the cornerstone, an indispensable and fundamental part, of the ability of the US to follow the global situation in order to decide in battle (fig. 2-2). They provide the US with the ability to collect, analyze, and fuse data into intelligence information under *diverse conditions,*

doing so *everywhere, continuously.* They provide the users with the information they need—anywhere and anytime.



Source: Clipart from Microsoft Clipart Gallery © 1995 with courtesy from Microsoft.

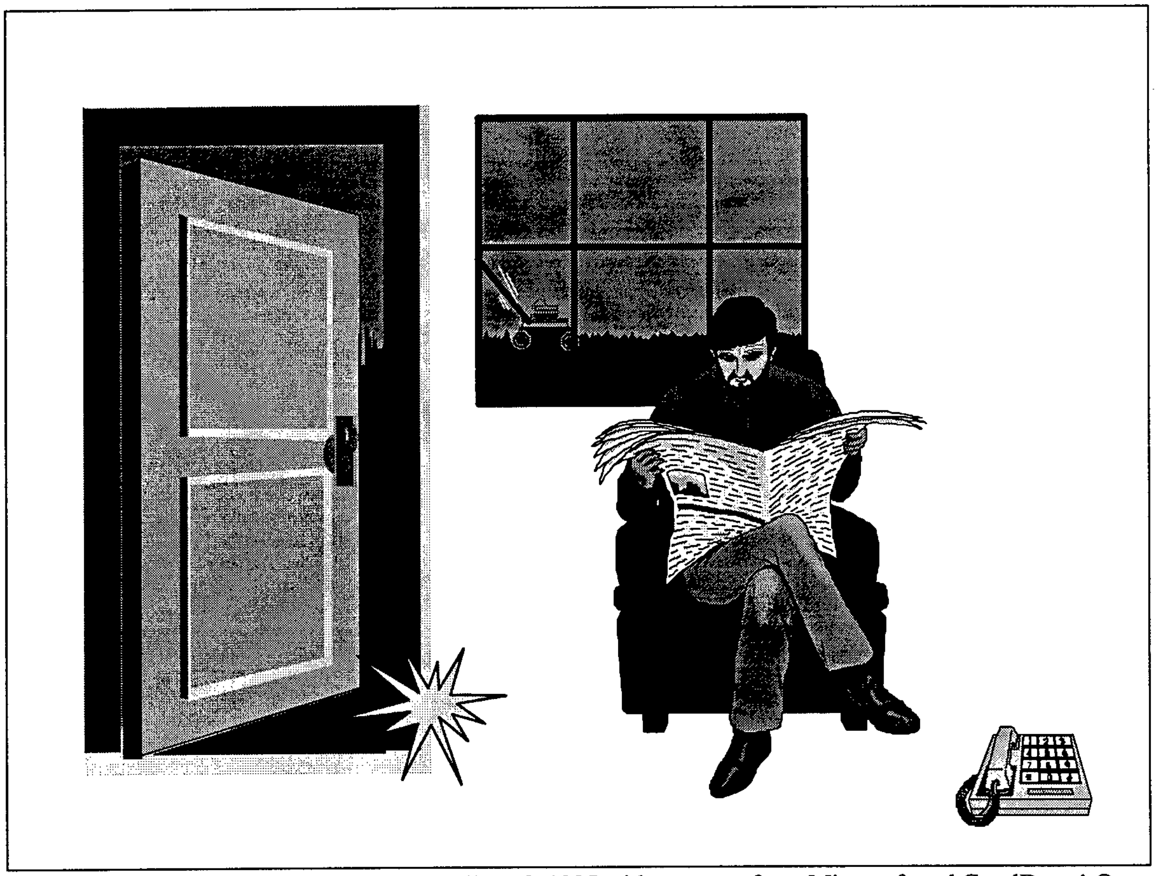
Figure 2-2. Following the Global Situation.

The "Man in the Chair"

Is there any system existing today that exhibits these capabilities required for the future? Yes! The human system—the senses, the nervous system, and the brain. Continually collecting, analyzing, and fusing data, it is aware of its surroundings and has the ability to focus on important events. It delivers the necessary information when needed for accurate decision making.

Let's look at an example—the "Man in the Chair" (fig. 2-3). Sitting in his study, a man is reading today's newspaper—his eyes and mind focused on the words at hand. At the same time, all his senses are

maintaining a continuous "picture" of all that is occurring in his surroundings. Without conscious effort, the man's brain receives information through his nervous system from his various senses, evaluates it for importance, stores it away for possible use, and determines if further action is required. Though "aware" of his surroundings, the man is not distracted by routine events—the conversation in the hallway, the smell of fresh cut grass coming through an open window, or the noise from the yardman mowing the grass. Suddenly, a door is slammed. The man's brain immediately brings his senses to focus on what has occurred. His ears tell him that a loud bang came from somewhere behind him.



Source: Clipart from Microsoft Clipart Gallery © 1995 with courtesy from Microsoft and CorelDraw! © 1994 with courtesy of Totem Graphics Inc.

Figure 2-3. The "Man in the Chair."

Several actions might now occur depending on what the man's brain has stored away. Recalling that everyone else had left the house five minutes before; the door to the study had been open; a strong wind was blowing through an open window in the other room; and having heard the sound of the study door slamming

on another occasion; the man might quickly and accurately conclude that the wind had blown the door closed. In this instance, the man's brain may not have brought other senses into play.

But what if the man does not have all this information stored away? In this case, the sound triggers the brain to focus its other senses on the event. First, the man turns so that he can see the area behind him. He notices the study door is now closed. Wondering how it was closed, he gets up, opens the door, and looks to see what is on the other side, "zooming" in to get a clearer picture of what has happened. He notices a strong wind blowing through an open window and thinks that maybe the wind has blown the door shut. Just to be sure he calls out "anybody there?" and walks through the rest of the house to see if someone is there.

As he moves through the house, all the man's senses are at a heightened state of alert and his brain is searching other stored information to anticipate what might happen next. All the while, the man's brain is collecting and fusing information from his senses to aid his decision making and is doing so almost instantaneously with little apparent effort.

A Model for 2025: MITCH

How does this analogy apply to a system that can meet the demanding challenges in 2025? Only an integrated system, one similar to the "Man in the Chair," one that maintains its own awareness of the global situation, can meet them.

The Air Force Scientific Advisory Board has identified this same major focus for the future: "to know at all times the relevant global military situation given the existing political and economic conditions and the state of military conflict." They believe "such awareness should be in near real time (in time enough to understand and act) and with near perfect knowledge (knowledge good enough to make good decisions in the time available to decide and act)."[13] This is the foundation for global awareness and information dominance. This is the "Man in the Chair"—MITCH.

Notes

[1] John R. Boyd, "A Discourse on Winning and Losing" (Paper presented at Air University for CSAF's *2025* project, Maxwell AFB, Ala., 27 September 1995).

[2] James R. Clapper, Jr., "Desert War: Crucible for Intelligence Systems," in *The First Information War*, contributing ed. Alan D. Campen (Fairfax, Va.: AFCEA International Press, 1992), 81.

[3] Harry E. Soyster, "Extending Real-Time Intelligence to Theater Level," in *The First Information War*, contributing ed. Alan D. Campen (Fairfax, Va.: AFCEA International Press, 1992), 61-62.

[4] The United States is credited with devastating Iraq's formidable military machine by exploiting knowledge and leveraging information. This is asserted in Alan D. Campen, ed., *The First Information War* (Fairfax, Va.: AFCEA International Press, 1992), ix.

[5] AFP 200-18, *Target Intelligence Handbook Unclassified Targeting Principles*, vol. 1, 1 October 1990, 11.

[6] The "first space war" designation was a result of the extensive use of space-based assets to carry out communications, navigation, surveillance, and meteorological projections.

[7] Sir Peter Anson and Dennis Cummings, "The First Space War: The Contribution of Satellites to the Gulf War," in *The First Information War*, contributing ed. Alan D. Campen (Fairfax, Va.: AFCEA International Press, 1992), 121.

[8] James R. Asker, "Space, Key to U.S. Defense," *Aviation Week & Space Technology* 138, no. 18 (3 May 1993): 57.

[9] John L. Petersen, *The Road to 2015: Profiles of the future* (Corte Madera, Calif.: Waite Group Press, 1994), 287.

[10] Maj Lori Colodney, "Getting Command and Control System Back into the Fight on the Digitized Battlefield," Fort Leavenworth, Kans., 17 December 1994, 22.

[11] Sun Tzu, *The Art of War*, ed. and trans. Samuel B. Griffith (London: Oxford University Press, 1963), 140.

[12] AFP 200-18, 11.

[13] USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century,* summary volume (Washington, D.C.: USAF Scientific Advisory Board, 15 December 1995), 57.

Chapter 3

System Description

The essence of the "Man in the Chair" is captured in a system called MITCH. With 2025 technology, MITCH offers the required capabilities of persistent global surveillance, responsive "zoom" of high-resolution reconnaissance assets, and intelligent fusion of data. It is the conceptual vision for providing the right product, in the right place, at the right time.

This chapter begins with a quick tour of MITCH as a system. What are the principle elements of the system? How do the elements fit together? How do they work together? With the "big picture" established, each subsystem will be reviewed in greater detail, including a look at the emerging technologies required to make the concept a reality. This discussion of hardware, software, and networks will be followed by a discussion of the role humans play in MITCH's training and development. Next, the chapter identifies MITCH's key vulnerabilities and considers friendly countermeasures to protect them. Finally, the last paragraph introduces the Air Force Institute of Technology's operational analysis of the concepts presented in ***2025*** white papers.

Before continuing, it is important to note that end users, either human or automated, and specific user hardware interfaces are not considered part of MITCH. Instead, MITCH's role is to create information and bring it to the point where users and their hardware can plug in and retrieve it. In other words, MITCH performs the observe and orient phases of the Observe, Orient, Decide, and Act (OODA) loop and leaves the decision and action phases to the human or automated decision maker (fig. 3-1). This system distinction emphasizes MITCH's collection and information processing aspects. At the same time, it recognizes a tremendous range of users and the way they will use information.

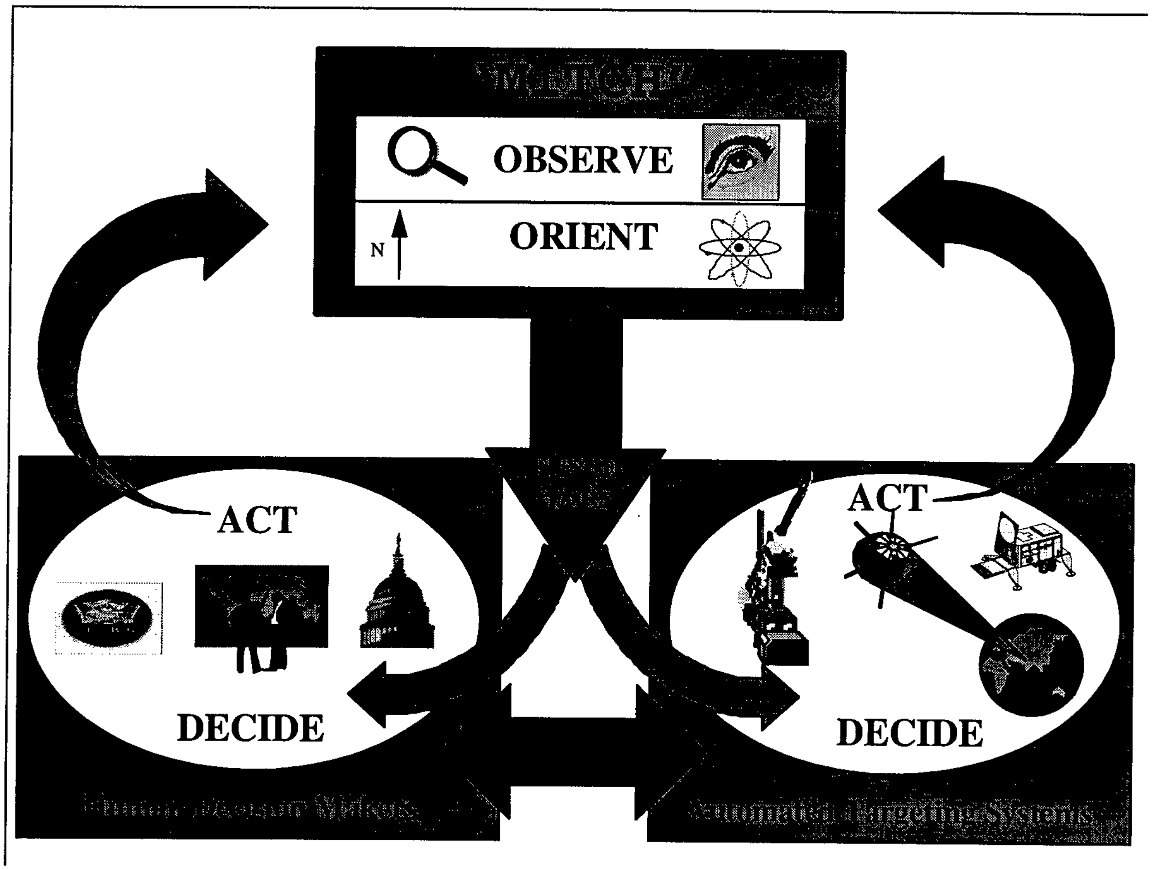


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Figure 3-1. MITCH's Role in the Decision Cycle.

The Big Picture

Think back to the analogy of the "Man in the Chair." In the simplest sense, two very basic processes are taking place. First, the man is collecting data on his environment. He sees, hears, touches, and smells. Second, the man is evaluating the data he collects. He correlates and responds to what his senses indicate. The two principle subsystems of MITCH—the SenseNet and IntelSpace—are built around these same two processes. Figure 3-2 introduces the conceptual illustration of MITCH and its components.

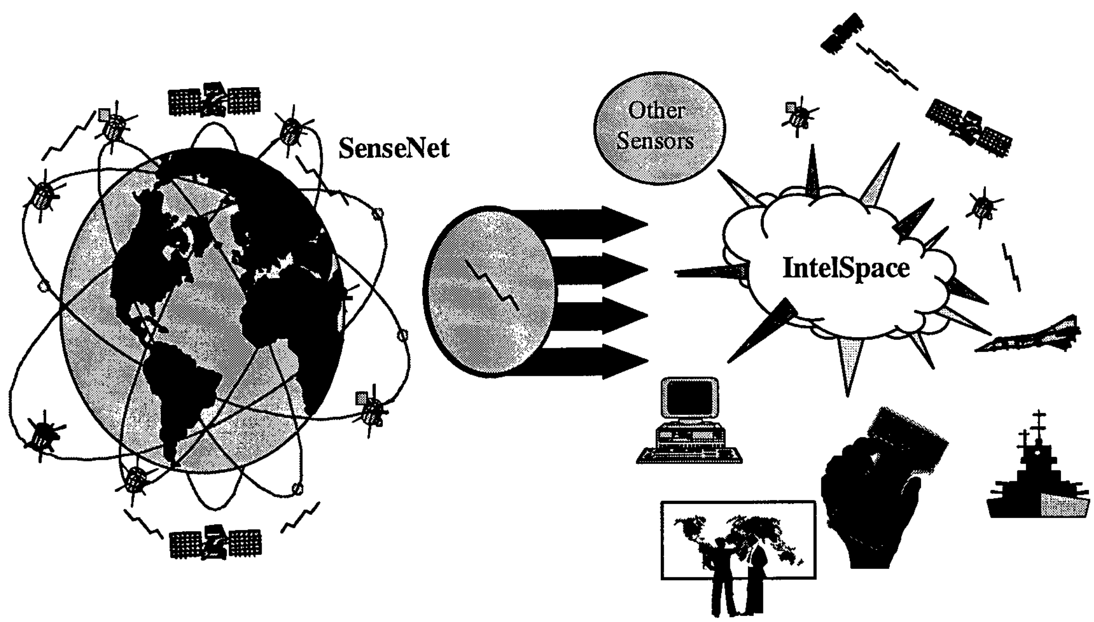

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Figure 3-2. MITCH.

The SenseNet is figuratively the "eyes and ears" of MITCH and consists of a constellation of sensor satellites (SENSAT) working continuously to provide persistent global surveillance, responsive high-resolution reconnaissance, and the first steps in data fusion. The SENSAT constellation hosts perhaps hundreds of SENSATs, each carrying one of many sensor types. This swarm of small or even microsatellites guarantees that a variety of sensor types can access any part of the globe simultaneously. The result is a richer "painting" of the global situation, made possible by the fusion of many different sensor "brushes."

Unlike today, where virtually all processing of space data is performed on the ground, the SenseNet will develop and maintain its global picture *on-orbit*. This approach is realistic for the 2025 time frame. Advances in microprocessing and storage capacity will permit SENSATs with revolutionary onboard capabilities. Each SENSAT will store data from past orbits and share that data with other like-sensored SENSATs through high-capacity communication links. As a result, each group of like-sensored SENSATs will build a comprehensive view of the world from that sensor-type—photographic imagery for example.

The SenseNet will then test all subsequent collections for changes. Changes are downlinked to MITCH's second principle subsytem—the IntelSpace.

The IntelSpace is MITCH's "brain" and "nervous system" and is best thought of in terms of an *information domain* and a *network architecture*. Both of these components are made up of mass storage systems, high-capacity communications, high-speed processors, user agents, and artificial intelligence.

As an information domain, the IntelSpace stands as a reservoir of knowledge. It fuses SenseNet data with inputs from other collection systems to create information and, in some cases, knowledge. For example, assume the SenseNet downlinked both visual and thermal data of a single strategic bomber. Optically, the bomber is sighted on a runway and, thermally, the engines are hot. When fused together, this *data* is now *information*—the bomber is active on the runway.

What then constitutes *knowledge*? Further fusion to permit interpretation of intent. If the IntelSpace noted from human intelligence (HUMINT) that all of the opponent's bombers were similarly configured and Navy signal intelligence ships showed the opponent's command and control structure active, it might conclude that a strike was imminent—a conclusion that would be forwarded to interested users. All of this means that the IntelSpace will recognize global patterns and learn through intelligent correlation of data. MITCH will put "two and two together"—often without human intervention.

In the final analysis, the ability to automatically fuse data and recognize patterns, in seemingly unrelated events, is the heart of what MITCH offers. Without this revolution in information processing, future users would drown in sensor streams pouring in from the SenseNet and other sources. One senior department of defense policymaker's current observation of joint task force (JTF) commanders would remain typical. This policymaker, speaking to Air Command and Staff College under the promise of nonattribution, stated JTF commanders are often forced to operate several different computer systems to ensure they have access to all the information they need. In one case, a JTF commander had seven different systems on his desk.

In addition to offering intelligent, semiautonomous fusion of all-source data, the IntelSpace also serves as a network architecture. In this role, the IntelSpace tasks the SenseNet and serves as the "highway" to get the right data, information, and knowledge to the right user, at the right time.

The IntelSpace autonomously tasks the SenseNet to support conclusions or respond to user queries. In the previous scenario, for example, a lone enemy bomber on the runway might prompt the IntelSpace to direct

immediate high-resolution reconnaissance collection against all runways. This direction would come in the form of collection instructions to the specific SENSATs appropriate to the problem. The IntelSpace knows where other runways are located, knows what sensor-types are applicable, and recognizes a "snap shot" of all runways is valuable information. In its second role—that of a highway—the IntelSpace is simply the conduit through which every user interfaces. Just like today's Internet, users will tap in through a myriad of platforms and access information spread around global sites. In 2025, however, the "surfing" is transparent to the user.

Having completed a quick tour of MITCH as a system, it is time to examine the SenseNet and IntelSpace subsystems in greater detail.

The SenseNet

The "Eyes" and "Ears"

As introduced earlier, the SenseNet is a constellation of small sensor satellites, or SENSATs, that serve as MITCH's "eyes" and "ears." Each SENSAT bears one of the many sensor types present in the total system (e.g., infrared [IR], radar, communications intelligence [COMINT], etc.). As a system, literally hundreds of SENSATs are carefully placed in complementary orbits that afford multisensor access to any spot on the globe, all the time. Today's global positioning system (GPS) constellation is a working example of this concept. This constellation of 24 satellites ensures at least four GPS satellites are continuously in view of any user location.

Whereas the GPS provides navigation data, SENSATs will provide continuous global *surveillance* at medium resolution and focused *reconnaissance* at high resolution. Each SENSAT will collect data as appropriate to its sensor type, improving the data's signal quality, removing redundant information, and finally, sharing that data across the SenseNet via a robust and redundant laser communication network. What emerges is a global "picture" of the world "painted" with different but complementary sensors. Each SENSAT will store an onboard "picture" of the world from its respective sensor type. Subsequent collections will be combed for changes. Only changes detected from the existing global "picture" will be

downlinked to the terrestrial IntelSpace. This concept greatly reduces routine data link usage and ensures capacity is available for surges and special tasking like "direct downlink" missions.

Typically, the surveillance SENSATs will be the first to detect change. When this happens, the IntelSpace may task the reconnaissance SENSATs over the region to collect high-resolution data. These high-resolution products can be essential to object recognition, submeter geopositioning, and some "fused" products. Stereo imagery is one example of the latter. Using raw SenseNet data generated by the simultaneous collection of a single location from two or more different angles, the IntelSpace can produce three-dimensional images of the scene.

SenseNet Components

The SenseNet architecture is broken out into three components: sensors, satellites, and the satellite constellation. These components work together to collect and communicate data to the ground.

Sensors. What are the *right* sensors? "Leveraging the Infosphere: Surveillance and Reconnaissance in 2020" offers a long list of candidates from multispectral imagers to radio signal interceptor systems to olfactory sensors.[1] Advances in technologies portend exciting advances in what phenomena can be observed and the detail to which they can be observed. The particulars of these sensors and the technologies that support them will not, however, be treated here. Instead, this paper focuses on a system that can fully exploit whatever the complement of sensors becomes. This approach draws attention to the satellites that will carry these sensors and their constellation.

Satellites. Properly *fusing* space surveillance and reconnaissance data requires putting the right *sensors* over the right *targets* at the right *times*. Very few intelligence questions can be answered with a single pass of a single sensor over a target, and yet that is all current systems generally permit. There are two solutions to this problem. Either build large satellites, each carrying a wide array of sensor types operating simultaneously, or build numerous small satellites, each with a single dedicated sensor. In 2025 the best answer for the SenseNet is the latter. Even today, large satellites can run a staggering $1 billion a piece; their loss would leave unacceptable "holes" in the mission constellation.

Small satellites, on the other hand, are low in cost for design, construction, and launch.[2] Proliferation of large numbers of these limited-function satellites also contributes to lower overall SenseNet system

vulnerability; any antisatellite (ASAT) attack on individual satellites would only marginally impact overall SenseNet performance. Further, any satellites lost to either ASAT attack or system failure can be quickly, easily, and inexpensively replenished.[3]

The road to 2025 promises satellites as small as a shoe box if current trends continue. Interest in them is growing quickly worldwide. Businesses, governments, universities, and other organizations around the world are starting their own small satellite programs.[4] Industry, lured by "smaller, faster, better, cheaper," is paying more for research in this area. As a result, technologies needed to support this trend are being developed and demonstrated at a tremendous pace. The International Small Satellite Organization (ISSO) reports 72 lightsats were launched between 1988 and 1994.[5] The Small Satellites Home Page of the World Wide Web, hosted at University of Surrey, United Kingdom, lists 46 small-, mini-, micro-, and nanosatellites currently preparing for launch before the turn of the century.[6] One of these satellites, "Clark" (named after the famous American explorer), has interesting commonalities with SENSAT concepts.

"Clark" is a small satellite project funded by NASA through its Small Spacecraft Technology Initiative (SSTI) program. It is scheduled to be launched in June 1996. This state-of-the-art satellite will carry a multispectral imaging camera that will provide multispectral image resolutions of three to 15 meters, completing global coverage in as few as 20 days at a total program cost of only $49 million (including launch).[7] The satellite is scheduled to fly on OSC's Pegasus XL launcher, an air launched rocket that does not require a conventional launch pad.[8] Clark will demonstrate 36 advanced technologies critical to small satellites. These technologies are listed in appendix B. Among them are "automated onboard feature identification" and "image data compression"—technologies that will be of great value in managing the massive data collected by the SenseNet.[9] The ramifications are clear. Small satellites are fast becoming the norm and enabling technologies should mature in time to support a SenseNet by 2025.

Constellation. The SenseNet unifies hundreds of satellites into a well-orchestrated whole. The result is a capability closely resembling "Man in the Chair" concepts. At all times, MITCH will be able to monitor any spot on the earth with surveillance SENSATs and focus with reconnaissance SENSATs in all "senses."

It is possible to construct a SenseNet constellation that guarantees more than one SENSAT of each sensor type over every point on the earth. In fact, this design prudently accounts for SENSAT maintenance,

look angles to the target, and obstructing terrain. Consider a midaltitude network that puts at least two like-sensored SENSATs over all terrestrial points. One simple version would be 18 satellites in circular midearth orbits of 7,000 to 8,000 kilometers (4,350 to 4,970 miles) inclined at 51 degrees to the equator. Three SENSATs would be dispersed in each of six distinct orbits to ensure two SENSATs over every point on the globe.[10] In practice, one such constellation would be required for each SENSAT sensor type. This means if 2025 warriors conclude they need seven different sensor types continuously monitoring all regions of the earth, the total system would involve 42 orbits carrying a total of 126 SENSATs.[11] The exact number is not so important at this point. What is important is the fundamental concept of a constellation of a hundred-plus satellites to achieve the global awareness of the "Man in the Chair."

Having addressed a constellation that maximizes SenseNet efficiency, it is important to also focus attention on SenseNet communications and data processing. All SENSATs are linked together by high-capacity laser communications that allow them to collaborate in onboard processing and cross-link data. Laser communication links may also tie the SenseNet to the ground-based IntelSpace and users. According to the Air Force Scientific Advisory Board's recent study, *New World Vistas: Air and Space Power for the 21st Century*, laser links will soon approach capacities of 40 gigabits per second (Gb/s)—the capability of state-of-the-art fiber optic lines in 1995.[12] The study concludes that just one of these 40 Gb/s links could pass enough bits to map the entire world with 10-meter resolution multispectral or synthetic aperture radar (SAR) data every hour.[13]

This conclusion is very promising for the SenseNet! Consider a constellation of 18 radar SENSATs, for example. If each satellite is equipped with one 40 Gb/s link, the entire world could be imaged at 10 meter resolution (including oceans and polar ice caps) every three and a half minutes. It is apparent that communications technology will not significantly constrain the SenseNet system performance. The Future Concepts Division at the USAF Command, Control, Communications, and Computers (C^4) Agency agrees. They expect immense communication capacity by 2025.[14]

The concept of only downlinking changes to the ground rests on the ability to process and store the current global "master template" on-orbit. *New World Vistas* estimates that a multispectral image of the entire earth requires 1,300 terabits of memory.[15] Although this is well beyond the storage capabilities of

current satellite data subsystems, industry experts expect significant progress in mass data storage and data processing technologies. By 2025, experts easily foresee memory and processing capacity sufficient to store a complete image of the earth and assess real-time collection for changes relative to that picture.[16]

SenseNet Control. SenseNet assets are controlled from the IntelSpace. Commands are uplinked to the SenseNet and the collected data is downlinked to the IntelSpace via a network of military and commercial communications channels. According to the Future Concepts Division of the USAF C^4 Agency, this network could span the globe, seamlessly crossing communication system boundaries (military and commercial) without intervention or awareness by users.[17]

On occasion, the IntelSpace will task the SenseNet to directly downlink SENSAT data to a user deployed in the field. For example, a near-real-time, sensor-to-shooter link could warn ground forces of in-theater surface-to-surface missile launches. Following such a request, the IntelSpace will task the SenseNet to collect with the appropriate sensor type in the region of interest. The SenseNet will allocate the tasking to a specific SENSAT, orchestrate collection hand-offs as SENSATs fade beyond the horizon, and facilitate "hand shakes" at the speed of light to relay collected data to a SENSAT in view of the terrestrial user. The last SENSAT to touch the data will then downlink the product to a user whose only action was to request the product from MITCH.

Emerging Technologies

The Clark technology synopsis contained in appendix B provides a basic guide to emerging satellite technologies that are critical to small, affordable, high-performance satellites in the future. Technology advances in electrical power, command and data handling, attitude determination and control, structures, mechanisms, and instruments make the SenseNet realistic by the year 2025. Commercial system engineering and development processes are already driving these advances.

One technology critical to the performance of small SENSATs, but not listed in appendix B, is the data processing algorithms needed to achieve large aperture (high resolution) system performance. This software digitally processes simultaneous multiple views from multiple satellites into a single, high-resolution picture. For many sensor types, resolution drives aperture size, which in turn, drives payload size. Typically, the

payload is the largest subsystem of any satellite. Large aperture processing is a powerful way of reducing payload size while preserving sensor resolution.

SenseNet: Only One Piece

Sensors, satellites, and constellations do not achieve information dominance by themselves. Without intelligent tasking and smart exploitation of collected data, these elements are nothing but scattered pieces of hardware in space. Further, the low cost and growing availability of these near-future space systems will grant America's future adversaries the same sensors, satellites, and constellations. The path to information dominance lies not only in collecting the most and highest resolution sensor data but also in using that data to deliver the right product, to the right place, at the right time. This is the function of MITCH's "brain" and "nervous system," the IntelSpace.

The IntelSpace

As the global "picture" is acquired by the SenseNet and received from other sources, it enters MITCH's second principle subsystem, the IntelSpace. The IntelSpace ties sensors of all kinds to users at all levels (fig. 3-3). It is important to understand that collection is not limited to SenseNet assets. Other sources, including HUMINT and a variety of air, land, and sea platforms, complement the strength of the SenseNet's "high ground." These sources provide data and/or information that may be undetectable from space. What emerges is an IntelSpace with vast potential to meet two required capabilities: fusion of all collected data into a global picture and single-point user access to the right information.

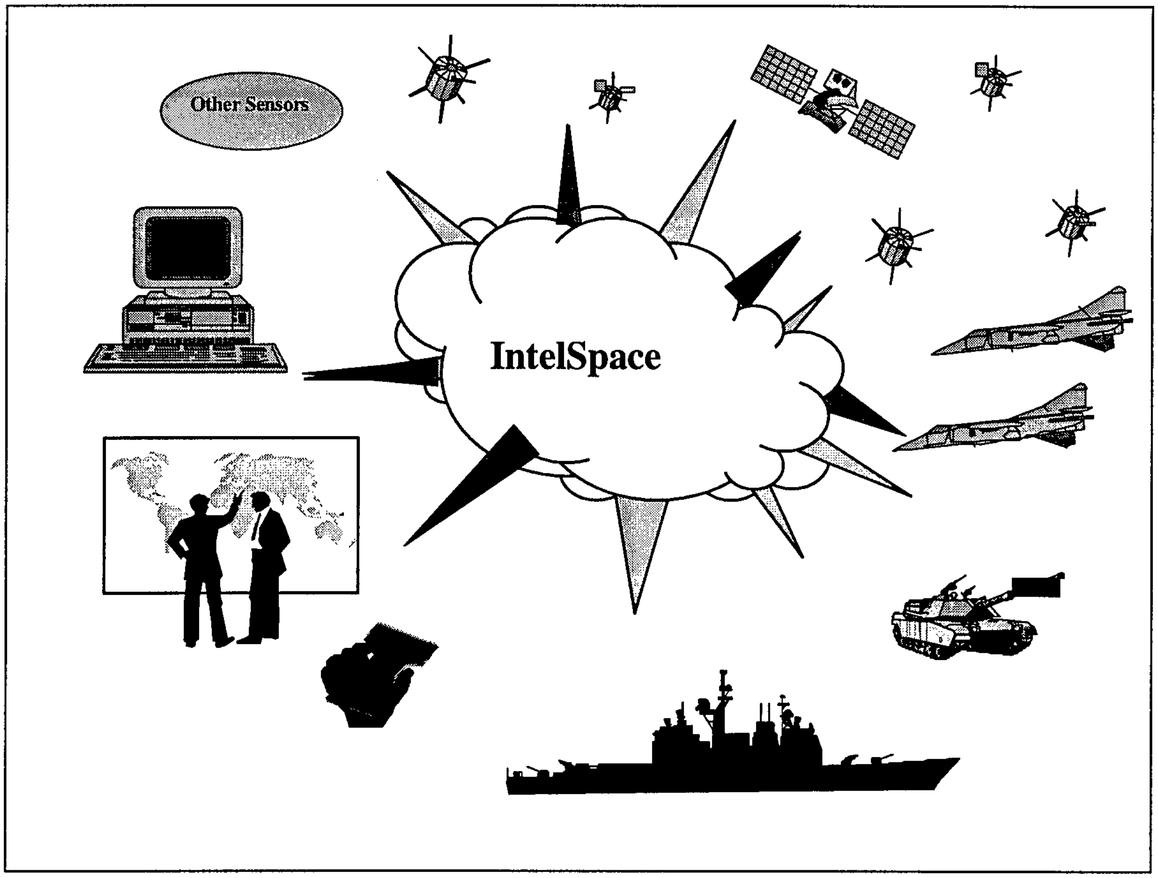

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Figure 3-3. The IntelSpace.

The IntelSpace *manages* intelligence information. As discussed earlier, it is subdivided into the Information Domain, MITCH's "brain," and the Network Architecture, MITCH's "nervous system." In the Information Domain, sensor data is fused, correlated, and stored to create intelligence information and knowledge. It is the sum total of what MITCH knows. Through the Network Architecture, sensor stimuli are relayed to the "brain" for processing; the results are then relayed to users. One could look at the Network Architecture as the "highway" that passes information between collector and user.

Software and hardware are fundamental to both the Information Domain and the Network Architecture. High-speed processors host conventional processing algorithms as well as less traditional artificial intelligence—neural networks, fuzzy logic, and user agents. High data-rate communications and massive storage banks send the right data to the right decision maker at the right time. Users receive this data through hardware ranging from simple personal digital assistants to complex aircraft displays. The following

discussion provides more detail on MITCH's "brain" and "nervous system" and highlights emerging technologies essential to each component.

Information Domain

As the "brain" of the IntelSpace, the Information Domain includes MITCH's analytical ability and the reservoir of intelligence that flows from it. The "engine" driving this analysis is a mixture of artificial intelligence (AI) that includes rule-based decision logic, neural networks, fuzzy logic, and agents. The AI components are smart enough to perform tasks traditionally accomplished by human analysts. When users query MITCH, the Information Domain searches stored data and initiates any new collections required to answer the question. Rule-based logic and trained neural networks make this possible by effectively "thinking through" or determining what data and information is needed to answer the request. Rule-based logic and neural networks also automate the analysis of data once it is collected. Each new piece of data is fused and correlated across the total Information Domain. In other words, new data is integrated with existing data to "paint" all facets of the situation, and it is interpreted within the context of other stored information. At the same time, AI components look for familiar and emerging patterns. These patterns are the building blocks for MITCH's conclusions. In the case of new, emerging patterns, MITCH may "push" conclusions on to the user without cueing.

It is worth noting that data fusion and pattern recognition at a global level are tremendously challenging, perhaps more so than any other aspect of MITCH. Although the technologies will be in place by 2025, their specific application to MITCH will almost certainly dwarf any similar efforts at the commercial level. Perhaps millions of data and information elements will require constant manipulation in response to an ever-changing world situation. That data will run a rigorous spectrum, ranging from simple temperatures to complex HUMINT reports on human intentions. In fact, it is probable that MITCH will require years of human massaging and on-line experience before it can reliably identify, test, and recommend patterns from that near-chaotic set of links.

Even after MITCH is fully initialized and running autonomously, AI will not replace humans in the system loop. Instead, it will augment the human by autonomously performing the myriad of logical tasks

associated with reduction of collected data. Decision making is still left to the human. However, decisions can be made without the burden of first sifting through "mountains" of stored data.

Network Architecture

The network architecture provides the underpinnings for the distributed connectivity and processing of the IntelSpace and serves as MITCH's "nervous system." The network will be widely distributed, much like today's Internet, ensuring survivability. If one node of the IntelSpace is damaged, the effect on the rest of the IntelSpace will be minimal. As with the Information Domain, the Network Architecture runs with conventional processing as well as AI elements. Using these technologies, the network manipulates and moves data back and forth from the SenseNet to the end users.

The Network Architecture, however, does more than just serve as a highway for data and information. Using neural networks, a network "architect" determines when and where to create new data reservoirs and how to link them to the system—providing for more efficient system operation as well as increased survivability. If tasking of the SenseNet is necessary at any time, the Network Architecture relays that tasking from the Information Domain to the SENSATs.

The *2025* concept paper "Automated and Integrated Intelligence Seamless Fusion and Correlation System" proposes neural networks to fuse intelligence data in response to user queries.[18] While this system uses direct user queries and messages rather than the autonomous user agents proposed later in this paper, this system provides a possible intermediate stage between the systems of today and those of 2025.

Emerging Technologies

In order to deliver the IntelSpace by the year 2025, specific technologies must be further advanced. These include artificial intelligence (rule-based logic, neural networks, fuzzy logic, and agents), high data-rate communications, mass storage media with fast input-output capabilities, hardware independence, and high-speed processing.

Rule-Based Logic. Rule-based logic is the first of four AI technology areas employed in the IntelSpace. In the start-up of any AI system, human operators preprogram this logic into the system through what is known

as preconditioning. This preconditioning establishes the logical paths from which the IntelSpace will frame its decisions and actions. For example, if SenseNet data shows movement of 300 tanks and the IntelSpace determines these tanks will cross an international border, how will the IntelSpace react? It will not—unless prompted by code that says: "If 300 tanks cross a border, report an invasion." This code is the *rule*. The strength of rule-based logic is its simplicity. Cause brings effect, however, the simplicity also fosters weakness. To properly account for all possible interpretations of a given situation, millions of rule-based statements might be required. How should the IntelSpace react if only a single tank brigade crosses the border? What about a squadron of fighters? What if the nations are participating in a joint exercise? The fact that rule-based logic exercises black-and-white decision criteria makes it unwieldy for complex problem sets. In addition, there is no way to autonomously adjust the logic for "experience." These two shortcomings are precisely the reason that AI has floundered over the years and disillusioned so many.

Fuzzy Logic. Along with neural networks, fuzzy logic capitalizes on the advantages of rule-based logic while offsetting that technology's weaknesses. Fuzzy logic allows computers to press beyond binary decision making into variations or approximations. Modern-day examples surround us: the thermometer of an air conditioner, the antilock brakes of a car, or the autofocus of a video-camcorder.[19] It is a discipline crucial to monitoring the global situation—a situation whose elements cannot be defined in one of two states. Returning to the example, fuzzy logic will allow MITCH to go beyond the elementary "300 tanks have crossed the border" and deal with approximations and shades of relative degree. Using this technology with stored data, the IntelSpace might evaluate tank speed, status of targeting systems, and nature of the tank formations to determine if the movement is similar to, or "approximates," hostile action. In other words, fuzzy logic allows MITCH to turn the raw data from the sensors into an intelligent assessment of the situation.

Although fuzzy logic significantly enhances the effectiveness of complex AI systems, it will not be enough to construct MITCH as envisioned. Neither rule-based nor fuzzy logic permit learning from experience. This shortcoming prevents the IntelSpace from becoming "smarter" than it was on the first day of operation. It means that recent experience, developing patterns, and new relationships would be retained only with the intervention of human operators. But a human role in this area would require tedious combing of data by analysts—precisely what MITCH is designed to eliminate!

Neural Networks. Neural networks are valuable to the IntelSpace because they "learn." They use experience to become better and better at classifying patterns. Exposed to enough examples, they generalize to others never seen. More significantly, neural networks can detect patterns no one knew existed.[20] When used with fuzzy and rule-based logic, this permits adaptive systems that can change with experience.[21]

Physically, neural networks are "computer-based systems that attempt to emulate the processing patterns of the human brain."[22] A typical neural network is made up of many interconnected processor elements simulating the neurons and synapses of a human brain.[23] Each processing element, or "neuron," receives a set of inputs from another element and processes the inputs through a summation function using a set of weights applied to each input value. Finally it applies a transfer function to the results to produce an output.[24] This output is then sent along a "synapse" to another "neuron" or fed back to the same processing element. The whole network is "taught" by adjusting the weighted strength of each "synapse" with experience. If we show the net a "G" and it properly responds with a "G," the synaptic connections are positively reinforced. The net will be more apt to follow that path next time.[25]

To put neural networks into the context of the IntelSpace, consider the example of the tanks crossing the border. Equipped with a neural network, the IntelSpace is now able to assess conclusions in light of *past experiences.* Assume the border in question is peaceful, the tanks are moving slowly, and the two countries in question normally conduct an annual training exercise between armored forces at this time of year. Based on the historical experience and the resulting strong links between "synapses" of the network's "neurons," MITCH would likely conclude the tank movement is friendly and not an immediate threat. MITCH would advise appropriate decision makers of the movement but also add the assessment that the movement was characteristic of normal activities between the two countries. Key decision makers would then determine what actions should be taken next. On the other hand, if the described links are weak or not present, the information is more likely to follow a path down "synapses" that would result in a warning that a hostile action may be occurring.

The commercial community continues to move forward in the area of neural networks and is successfully applying them to pattern classification, prediction and financial analysis, and control and optimization.[26] Pattern classification and control and optimization hold the most promise for the IntelSpace.

Pattern classification, for example, is being tested for its ability to detect events in complex particle accelerators.[27] In 2025, one can imagine this capability being used by the IntelSpace to detect events across the globe. Control and optimization research is quickly progressing in such areas as missile guidance and detonation, fighter flight and battle pattern guidance, and optical telescope focusing.[28] This research may prove useful in command and control of the SENSAT satellites and sensors.

User Agents. Another emerging technology that plays a key role in MITCH is software user agents. These agents make complex tasks transparent to the user by autonomously collaborating with other user agents and monitoring information.[29] Across the IntelSpace, agents may filter, receive, and detect changes to information. Agents are tailored to the individual user and "learn" user preferences by four different means: observation and imitation, positive and negative feedback, explicit instructions, and advice from other agents.[30]

Having learned the basic preferences and requirements of its user, an agent starts to collect information. If the information is not quite what the user wants, negative user feedback trains the agent to a different course of action. Each time the agent interacts with the user, it learns more about that user's needs.

Technology for autonomous agents is already in its infancy. An *Association for Computing Machinery* article addressing autonomous agents discusses four different existing agents: an agent for handling electronic mail, an agent for scheduling meetings, an agent for electronically filtering news, and an agent that recommends books, music, or other forms of entertainment.[31] Each agent "learns" the likes and dislikes of its user to determine what mail to keep, what time to schedule meetings, what news articles to send to the user, and what forms of entertainment to recommend. Carrying these tasks into the realm of the IntelSpace, a user agent could "learn" what type of intelligence data its user wants to see. The agent learns what intelligence information a user prefers in much the same way human assistants learn the same from their supervisors.

High Data Rate Communications. As computer systems get smarter, faster, and more dispersed, they demand faster and higher capacity communications. This will especially be true for the worldwide network of superprocessors that make up the IntelSpace. Fortunately for the military, the pressures of shrinking OODA loops are felt by the commercial and private sectors as well. As John L. Petersen wrote in his book, *The Road to 2015*, "Everything is going faster, so speed is increasingly being used to measure value."[32] The

commercial sector is vigorously responding with initiatives to comply. The Internet is already a significant driver for more robust communication links. The prospect of millions of users and consumers "surfing" the Internet has computing industry giants looking for ways to make the Internet more attractive to the average person.

One aspect of that attractive "packaging" will be faster and higher capacity communications. This imperative on speed and bandwidth has already spawned today's fiber-optic networks. These networks transmit voice, video, and data 10 to 100 times faster than standard copper wiring. Speeds will increase in the near term as performance-limiting interface hardware and electronic transmitters are replaced by optical components.[33] Further advances in all-optical networks are on the horizon. These networks promise another order-of-magnitude leap in transmission rates and capacities.

Mass Storage Media. The IntelSpace will store massive volumes of data on physical devices distributed across the network. It will require quick access to any piece of data at a moment's notice. Optical storage devices, like CD-ROMs and DVDs (digital video disks), foreshadow advances in data storage and accessibility. Researchers are moving to produce the first rewriteable optical storage devices. These rewriteable CD-ROMs employ two technologies: a high-power laser that changes the media's crystallinity and magneto-optical technology that changes the magnetic polarity of spots on the disk.[34]

Another emerging storage technology is holographic memory. This technology leverages recent three-dimensional optical memory advances to store tremendous amounts of information at very high speeds.[35] Holographic memory systems have been sold recently for use in security systems that retrieve and match fingerprints. Using optical neural networks for pattern recognition, these systems have been retrieving data at speed of a gigabyte per second.[36] Currently, this type of high-capacity mass storage system is only available for write once, read many (WORM) applications, but it may be the next step towards the mass storage systems of the twenty-first century.

Hardware Independence. To make it easier for decision makers at all levels to tie-in to the IntelSpace, hardware independence is a necessity. Just five years ago, networking computers in an office required they be compatible with each other. In most cases, this meant the hardware and associated operating systems had to be the same or at least similar. The Internet is changing all that. Systems using Windows, UNIX, Macintosh, and other operating systems are now "communicating" with one another. However, this

communication still requires system-unique software specifically designed to read a common language such as the hypertext markup language (HTML) of Internet home pages.[37]

Further simplification of network hardware and software requirements remains attractive. Software companies are responding by designing computer languages tailored to network computing. For example, Sun Microsystems is launching Java, a language that runs on any machine with a small Java "virtual computer."[38] Any computer hosting this "virtual computer" can run Java programs resident on any other hardware on the network. The small size of the "virtual computer" code, only 64,000 bytes, suits personal digital assistants and cellular phones very well.[39] Further competition for Internet market share will hone hardware independence to a fine edge. Tapping into the IntelSpace from the battlefield to the White House will not be a problem in 2025.

High-Speed Processing Technology. High-speed processing technology is another area holding great promise. Today, microprocessor performance is doubling every 18 months.[40] If performance continues to increase at that rate, processing power will be phenomenal in 30 years. According to one expert, in the year 2020, one desktop computer will be as powerful as all the computers in Silicon Valley today![41]

The Human Role

The preceding sections outlined a system architecture with powerful capability. In fact, the "cognitive" and processing aspects of MITCH are so promising that some would be tempted to view this system as omniscient or "all knowing." This presumption would be a mistake. MITCH, for all it offers, still must be seen as a tool to assist the human decision maker. It is a system that first *observes* and then *orients* those observations to a set of logical hypotheses. MITCH attempts to make sense of the global situation. It will never, however, be so certain in all its hypotheses that it can assume responsibility for decisions and actions. MITCH is *not* omniscient and war fighting is too often illogical. Clausewitz had it right: "The art of war deals with living and moral forces."[42]

Training MITCH

Since war is a human endeavor, MITCH must be initialized and trained with humans at its side. Initialization will predictably start with the objects to be observed and the metrics by which they are to be measured. In other words, humans must identify objects like a T-64 tank and then specify the tank's characteristics. The T-64 tank, for example, has a specific visual, thermal, and signals profile. It moves at particular speeds. It is normally found in certain regions or countries. In essence, the human trains MITCH to recognize objects and prepares it to evaluate all related aspects of that object. The human's next task is to train MITCH to link objects together. The challenge is that the permutations are seemingly infinite and any attempts to manually limit them would be counterproductive. In that regard, MITCH's ability to "learn" provides a solution. Rather than specifying each possible link, humans can train MITCH using historical events. MITCH could search for objects it knows and establish links with other objects based on the historical record.

The last step in MITCH's training is also one that never ends—creating information, and in some cases knowledge. Whereas previous tasks rested on MITCH's ability to recognize patterns in physical objects, this task requires it to recognize abstract patterns in the global situation. Intangibles like time, doctrine, and past experience are linked with more tangible observations to recommend hypotheses. As these hypotheses are evaluated and acted upon by human decision makers, MITCH will require human adjustments. These adjustments will range from the addition of new object links to the input of patterns clarified through 20/20 hindsight.

Training the Trainer

The quality of MITCH's mission contribution rests with the quality of its training at the hands of human tutors. Garbage in, garbage out. Brilliance in, brilliance out. The human trainers have to be well-versed in objects, links, and abstract patterns. However, their education does not end when MITCH is declared operational. On the contrary, MITCH is truly successful when it becomes good enough to train the trainer.

Consider the case of Chase Manhattan Bank. Once that institution trained a neural network in all the variables associated with bogus credit card purchases, the system then trained the trainers. That neural

network poured over historical data and discovered that the most dubious sales were for women's shoes priced at $40 and $80.[43] The neural network had created *new* information and passed it back to its human masters. MITCH will provide similar insights. Not only will human analysts benefit from new information, but they will also learn from the way in which MITCH determined it. Indeed, one of MITCH's indirect contributions may be to expand the horizon of analytical thought and stretch the efficiency of what is still the world's most versatile computer, the human brain.

Countering Countermeasures

MITCH is a highly distributed system, tying numerous satellites to an expansive ground network of processing and communications hardware. As a result, loss of any one part of the system will have only a small impact on MITCH's overall performance. Vulnerabilities, though somewhat limited, exist and they include both physical and informational aspects.

Countering Physical Attack. Proliferation and networking counter the threat of physical attack against both SENSATs and the IntelSpace. Any attack on a network node would endanger only a small percentage of the total system capability.

Hundreds of small, inexpensive, networked satellites make targeting SENSATs a very expensive operation for any adversary. This countermeasure can be further strengthened by launching redundant satellites or by developing a launch capability that can deploy several satellites on-orbit with only short notice. Certainly the proposal to use smallsats in MITCH begs for such a launch program.

Proliferation and networking also counter physical attack on the IntelSpace. In 1969, the DOD kicked off a project called ARPANET. That project reduced the vulnerability of critical computers by dispersing them for survivability and networking them for reliability. That reliability depended on dynamic rerouting. If one of the network links were to come under attack, the traffic could automatically be rerouted across other links.[44] Today, the ARPANET has blossomed into what we know as the Internet and its resistance to attack was demonstrated in the Gulf War of 1991. In that war, the US military struggled to completely knock out the Iraqi command network. It seems the Iraqis used commercially available network routers with standard

Internet routing and recovery technology. Proliferation and dynamic rerouting worked.[45] These principles are proposed again for MITCH's IntelSpace architecture.

Countering Deception and Security Breaches. Countering the threat to MITCH's informational integrity boils down to keeping bad data out of the system and bad people off the system. Since MITCH is automated to a degree, bad data is most dangerous when interjected through enemy deception. Deception intentionally misrepresents the enemy's intentions through legitimate collection and hopes for a favorable cascading effect in the IntelSpace's conclusions. Two design features of MITCH counter this threat. First, the number, type, and around-the-clock nature of SENSATs make any cohesive attempt at major deception a significant undertaking. The deception must play to numerous sensors and orchestrate a bogus story through imagery, communications traffic, thermal sensors, and many others. The deception must endure without pause since SENSATs will always be in view. Second, should the enemy achieve these objectives, MITCH's human interface serves as a valuable second check.

Preserving information integrity by keeping bad people off the IntelSpace leads to a tried-and-true security measure: individual authenticators. MITCH will support perhaps tens of thousands of access points, from an infantryman's pocket communicator to a super computer in a large intelligence operation. With so many entry points, the chore is not to prevent unauthorized possession of access media, but rather to prevent unauthorized system entry when that access media falls into the wrong hands. In MITCH, the required authentication of users could draw on a fusion of sorts, the fusion of state-of-the-art password technologies, deoxyribonucleic acid identifiers, retina scans, fingerprint scans, voice recognition, and others. In addition, the IntelSpace will allow authorized users to only access the data they "need to know," thus limiting the damage of any given compromise.

Operational Analysis

The system architecture and emerging technologies presented in this chapter deliver the five required capabilities central to core competencies of global awareness and information dominance. Together, MITCH's SenseNet and IntelSpace provide and protect the right product, in the right place, at the right time.

However, MITCH will not be evaluated solely on its ability to meet proposed requirements. Shrinking government budgets demand that it must also offer more "bang for the buck" when compared to a diverse range of other initiatives that also meet their requirements. The ***2025*** effort recognizes this demand and is conducting an operational analysis at the Air Force Institute of Technology (AFIT). In that analysis, the AFIT operational analysis team created generic tasks, force qualities, and measurands to score all ***2025*** concepts. Appendix C addresses these tasks and their subordinate metrics in the form dictated by the AFIT team. It rates MITCH's predicted system performance for each and justifies the values assigned.

Notes

[1] SPACECAST 2020, Air University, "Leveraging the Infosphere: Surveillance and Reconnaissance in 2020," AU study, 22 June 1994.

[2] R. A. da Silva Curiel (No date). *The Small Satellite Home Page* on-line internet, 12 February 1996, available from HTTP: http://www.ee.surrey.ac.uk/CSER/UOSAT/SSHP/sshp.html.

[3] The ***2025*** white paper "Spacelift" defines a path to a cost-effective solution to the replenishment question. Its air launched space vehicle (ALSV) would provide a completely reusable vehicle that is safe, responsive, and cost effective. Each of these vehicles would be able to provide up to three satellite launches per day with a surge capability of 12 space sorties per day for a period up to a week long. This would be a robust and adequate replenishment capability should the SenseNet suffer even a significant loss of SENSATs.

[4] Da Silva Curiel (No date). *The Small Satellite Home Page* [Online].

[5] William Gande, "Smallsats Come of Age?" *Ad Astra* 6, no. 6 (November/December 1994): 22.

[6] R. A. da Silva Curiel (No date). *Satellites in the making* . . . on-line internet, 12 February 1996, available from HTTP: http://www.ee.surrey.ac.uk/CSER/UOSAT/SSHP/future.html.

[7] CTA Incorporated (No date). *Clark Technology Synopses*, on-line internet, 12 February 1996, available from HTTP: http://www.futron.com/clark/clark.clark.html; Da Silva Curiel (No date). *Satellites in the making . . . .*

[8] Gande, 22.

[9] CTA Incorporated (No date). *Clark Technology Synopses* [Online].

[10] William B. Scott, "Russia Pitches Common Early Warning Network," *Aviation Week & Space Technology* 142, no. 2 (9 January 1995): 46.

[11] The preceding data recommends six orbits for each sensor type and if seven sensor types are desired, the number of orbits required is 42. To provide global coverage, three satellites are required per orbit resulting in a total of 126 satellites.

[12] USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century,* summary volume (Washington, D.C.: USAF Scientific Advisory Board, 15 December 1995), 20.

[13] Ibid., 23.

[14] Notes from meeting with the Future Concepts Division, USAF C^4 Agency, 28 February 1996.

[15] *New World Vistas,* summary volume, 20.

[16] John Verity, "Meet Java, the Invisible Computer," *Business Week* 3452, no. 1 (4 December 1995): 83.

[17] Notes from meeting with the Future Concepts Division, USAF C^4 Agency, 28 February 1996.

Notes

[18] *2025* Concept, No. 200059, "Automated & Integrated Intelligence Seamless Fusion & Correlation System," *2025* Concepts Database (Maxwell AFB, Ala.: Air War College/*2025,* 1996).

[19] Bart Kosko, *Fuzzy Thinking* (New York: Hyperion, 1993), 182–185.

[20] Daniel McNeill and Paul Freiberger, *Fuzzy Logic* (New York: Simon and Schuster, 1993), 229.

[21] Kosko, 203.

[22] Carol E. Brown, James Coakley, and Mary Ellen Phillips, "Neural Networks: Nuts and Bolts," *Management Accounting (USA)* 76, no. 11 (May 1995): 54.

[23] Kosko, 206.

[24] Brown, Coakley, and Phillips, 54.

[25] McNeill and Freiberger, 230.

[26] Bernard Widrow, David E. Rumelhart, and Michael A. Lehr, "Neural Networks: Applications in Industry, Business and Science," *Communications of the ACM* 37, no. 3 (March 1994): 94.

[27] Ibid., 95.

[28] Ibid., 96.

[29] Pattie Maes, (1994), "Agents that Reduce Work and Information Overload," *Association for Computing Machinery. Communications of the ACM* [Online], 30. Available: ProQuest Online [1996, January 27].

[30] Ibid.

[31] Ibid.

[32] John L. Petersen, *The Road to 2015: Profiles of the Future* (Corte Madera, Calif.: Waite Group Press, 1994), 70.

[33] Vincent W. S. Chan, "All-Optical Networks," *Scientific American* 273, no. 3 (September 1995): 56.

[34] Suzanne J. Thompson (No date). *Mass Storage Technologies* on-line internet, 14 February 1996, available from HTTP: http//www.nml.org/publications/NML_TR/task4_final/9_mass_ storage.html.

[35] Clarence A. Robinson, Jr., "Holographic Storage Media Could Eclipse Optical Disks," *SIGNAL* 50, no. 6 (February 1996): 31.

[36] Ibid.

[37] Amy Cortese with John Verity, Kathy Rebello, and Rob Hof, "The Software Revolution," *Business Week*, no. 3453 (4 December 1995): 78.

[38] Verity, "Meet Java, the Invisible Computer," 82.

[39] Ibid., 83.

[40] David A. Patterson, "Microprocessors in 2020," *Scientific American* 273, no. 3 (September 1995): 51.

[41] Ibid.

[42] Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, N. J.: Princeton University Press, 1976), 86.

[43] McNeill and Freiberger, 229.

[44] John R. Levine and Carol Baroudi, *The Internet For Dummies*, 2d ed. (Foster City, Calif.: IDG Books Worldwide, Inc., 1994), 11.

[45] Ibid., 12.

Chapter 4

Concept of Operations

Never before have armies been challenged to assimilate the combined weight of so much change so rapidly. In this environment, the payoff will go to organizations which are versatile, flexible, and strategically agile, and to leaders who are bold, creative, innovative, and inventive. Conversely, there is enormous risk in hesitation, undue precision, and a quest for certainty.

—Gen Gordon Sullivan
US Army chief of staff

Though directed towards an Army audience of today, these words embrace both the challenges and keys to success in almost any foreseeable future of 2025.

MITCH stands as a revolutionary step beyond the traditional intelligence-gathering systems of today. The preceding chapter described the system and the technologies that could make MITCH a reality. However, the "Man in the Chair" concept requires more than just a system. It also requires a new way of thinking about how we interact with the intelligence systems. To provide the right product, to the right user, at the right time, MITCH must be more than an evolutionary combination of year 2025 processors, sensor and satellite technologies, and communications. Only when tied to an effective concept of operations will MITCH meet requirements such as the Army's Force XXI "efficient, effective, tailorable, and flexible intelligence support in multiple locations."[1] The concept of operations for MITCH includes the following three key areas:

1. "Push You/Pull Me" information flow,
2. Global "PlugIn Play," and
3. "Right Product" for all operational levels.

Though these concepts have been briefly introduced before, they are covered in full detail here since they are a critical part of MITCH's capabilities. This chapter also discusses how users and decision makers at all levels would be supported by and interface with the system. Finally, to bring together the elements of MITCH's system design and concept of operations, a vignette illustrates how MITCH would participate in future operations.

"Push You/Pull Me"

The first concept, "Push You/Pull Me," is really the core operational concept of the system. "Push You" refers to the ability of the system to *cue* the user when the system finds information that might be critical and/or relevant. "Pull Me" means that the user would be able to request and receive specific information on demand. The specific details of each "Push You/Pull Me" operation would be performed by agents working within the network previously discussed. For example, the commander of a tank brigade might request a current display of his forces and those opposing him. His agent, continually monitoring the location of the tank brigade, would acquire the necessary information from wherever it was located on the system and subsequently display it—much like current agents that can locate and display information from the Internet's World Wide Web. The tank brigade commander *would not need to know where or how to get the desired information*. His request to the system simply "pulls" the information needed.

On the other hand, the system would also be able to provide *unsolicited cues* of critical activities that might otherwise go unnoticed or unasked for—critical activities that could mean the difference between victory or defeat in the global battlespace. For example, in surveillance of the battlespace, the system might identify unusually large numbers of trucks moving from rear-area supply depots towards the front. The system would cue leaders not only to the movement but also, because of assimilation of historical and current data, to further actions the enemy might be preparing to take. On request, MITCH could provide detailed rationale supporting those conclusions.

Global "PlugIn Play"

The second concept, Global "PlugIn Play," means that any user can "PlugIn" to the system from any place, any time, and immediately "Play" or operate on the system. This concept of operations also includes the ability of additional sensors to "PlugIn" to the network and have immediate data "Play" or integration into the IntelSpace. "PlugIn" could be by almost any form of communication media including fiber optics, satellite link, conventional radio, and laser. End users could "PlugIn" from any operational level. The "Play" concept eventually goes beyond the idea of just accessing (in the case of the user) or providing (in the case of a sensor) data. Combined with the "Man in the Chair" concept, "Play" takes on a more human definition—becoming an integral part of an activity. It means that the system not only provides information to each user but also improves the quality of information on the system through what it "learns" from interactions with each user. In addition, with the "PlugIn" of new sensors, the system does not just provide different displays to users; it integrates or "Plays" the information into the system to refine and improve the quality of information.

"Right Product"

The final concept of operations, "Right Product," means just that. The system will provide an integrated, timely product to any user—strategic, operational, or tactical—in the format needed by that user. Going a step further, the system could use personal software agents to provide tailored products to each individual user. For example, as users access the system, a personal agent would be created that would "interview" the new user to determine what level of operational information is required as well as learn specific information important to that user. The more the user uses the system, the more the agent would be able to "look over the shoulder" of the user and eventually anticipate what information the user would require. The agent may acquire that information and display it in the most effective manner. In addition, the agent would continuously monitor the system and alert the user when it found any information which might be critical. Relevance of information would improve as the agent learned from user feedback.

Finally, the agent could "ask for advice" from other agents that performed similar tasks to determine appropriate actions for a given situation. These concepts all build upon software agents already in existence or under development. Existing agents already discussed perform such tasks as filtering electronic news to find desired pieces of information, recommending books based on preferences of the reader, and automatically classifying concepts from electronic meetings.[2] These "agents" help bring "life" into the "Man in the Chair" concept. They provide the triggers that cue the "man" to focus his attention in a given area and subsequently acquire the information through his different "senses."

A Word on Users

The tenets of "Push You/Pull Me," "PlugIn Play," and "Right Product" seek to guarantee that MITCH is flexible enough to meet all users' needs on their own terms. By not focusing on specific user interfaces and systems, these three generic capabilities provide user access for any mission, across any medium, and in any format. In a manner of speaking, it is MITCH's job to provide the proper information; it is the user's prerogative to decide how and where that information should be exploited. Even though the user lies outside MITCH's formal system boundaries, it is still beneficial to discuss that community in general—if only for the purpose of reinforcing how flexible MITCH really is.

Supporting Users across Any Mission and Medium

To begin, MITCH is able to support users in any mission and across any medium. It accomplishes this support through a robust dispersion of assets across the SenseNet and IntelSpace. "PlugIn Play" is a key concept; it allows users at all levels of war to leverage their efforts with MITCH, no matter where they are.

The phrase "users at all levels of war" typically leads many to envision a wide range of personnel engaged in strategic, operational, and tactical tasks. It helps capture the idea that MITCH offers advantages to a range of decision makers from the White House to the lowest enlisted ranks. This interpretation, while correct, should be expanded to recognize that the 2025 user may increasingly be another machine or computer. In that time frame, some mission areas will be optimized by removing humans from the decision

loop. As the OODA point approaches, automated action may succeed where human decision and action may fail.

Theater missile defense exemplifies one area where MITCH, coupled with target acquisition systems, could provide a decisive edge. By exploiting MITCH's global awareness and its ability to pinpoint objects with sub-meter accuracy, enemy threats quickly become targets. The increased presence of surface-to-air missiles, ground-launched cruise missiles, advanced aircraft and armor, and highly motorized infantry, pushes war fighters toward an automated philosophy of "shoot now and ask questions later."

User Interfaces

Whether human or machine, users will view MITCH's information via an exciting array of formats. Each format must be tailored to specific mission areas with the goal of expediting decisions and actions. The spirit of this goal and the demands of 2025 probably sound the death knell for today's two dimensional displays. Instead, envision 3-D holographic displays of the situation, voice exchanges, tactile inputs that prompt actions, and other alternatives. Advances in miniaturization will allow "displays" on every weapon system, including the soldier. Imagine devices that inhabit the human body, closely integrating with human ears, eyes, and fingers. In the end, MITCH is designed to take advantage of any of these approaches. It is the user's call to make.

MITCH at Work

MITCH can make a reality out of today's and the foreseeable future's seemingly impossible tasks—providing the needed cornerstone of global awareness and information dominance. This system could monitor the globe in near real time, constantly looking for events that could change the strategic landscape. At the same time, MITCH would provide operational commanders with the "fused" information they need to ensure success on the battlefield. Finally, combined with the right strike vehicle, the system could enable the air and space forces of 2025 to achieve such current Air Force goals as "get those [ballistic missiles] with attack operations before they ever have a chance to launch."[3] In short, MITCH is a system that would

provide fused products (integrated, analyzed, right place, right time) to users including the president of the United States, theater commanders, fighter pilots, or infantry squad leaders.

The following illustration shows how MITCH might be incorporated in tomorrow's operations:

> The date is 1 January 2025. Over the last decade, portions of the SenseNet have been carefully placed in orbit above the earth. Today, the SenseNet is constantly watching, constantly looking for change, constantly learning about events occurring on the distant earth below. At present, the network consists of five types of small and microsatellites, all in low earth orbit. The constellation, each sensor type providing a separate "sense" to the network, is arranged to ensure global coverage at all times. Currently, the SenseNet is capable of multispectral imaging, signal intelligence, optical imaging, magnetic signature detection, and synthetic aperture radar imaging. Additions to the constellation will be added over the following years to increase sensor types and improve "awareness" of the system.
>
> As each satellite circles the earth, it maintains an independent and total database of the earth's surface for its particular sensor type. As it scans the surface, it relays changes in that database to other satellites in the constellation and to the IntelSpace below. New information is distributed throughout the IntelSpace to ensure the system cannot be rendered inoperable by the loss of any one or even a number of nodes. Just like the "Man In The Chair," the system is constantly combining information from all its "senses" into a single picture of the surface. Working constantly and in parallel, much like the synapses in the human brain (but at a much larger scale), system agents analyze this global image to identify all aspects of what is on and above the earth below. System agents cross check their "views" on global events in a way similar to an intelligence staff working together to provide a commander with the best possible "picture" of a situation. Like the "Man In The Chair," the system synthesizes what it "sees" into a much broader understanding of events.
>
> By the 4th of January, MITCH pieces together Iranian intentions to launch a new attack on Iraq. The system notifies the president, secretary of defense, Joint Staff, EASTCOM staff, and other key agencies and individuals of the activities. When queried by the president, the system displays a graphic image of the Iran/Iraq border and, using appropriate symbology, displays five armored and infantry divisions moving toward the border. Upon voice command, the system zooms in on a specific area and shows the president the individual vehicles it is tracking. In conjunction, the system provides the president with communications intelligence supporting the system's analysis.
>
> At the same time in another part of the globe, the commander of JTF LIFE GUARD arrives at his headquarters for his second day of humanitarian operations in India. To date, over 10 million people have died from massive floods within the country. The prime function of his task force is to locate people who have been isolated by those floods and provide them with needed supplies for survival—a stopgap until the waters retreat. As the JTF commander steps into the operations room, MITCH has already identified key populated areas isolated by flooding and has identified the location of people within those areas. The JTF commander quickly assigns his available airlift assets to deliver supplies to those areas.
>
> Back in the Persian Gulf region, MITCH has continued to monitor the situation between Iran and Iraq. The United States, as part of a coalition of United Nations forces, has a squadron of transatmospheric strike vehicles on alert to respond immediately to any offensive actions by Iran. At 2003 zulu on 5 January, MITCH alerts the president, national command structure, and strike squadron commander that Iran has prepared eight "Tehran" theater ballistic missiles for immediate launch. Three of the five armored divisions are shown rapidly moving toward the border. Upon this notification, the president orders the

strike vehicles to immediately respond if Iran crosses the border and to destroy the missiles if Iran decides to use them.

On board the strike vehicles, MITCH provides information to onboard computers for a continual display of the route to the theater. Upon request by the pilots, each agent displays the tactical situation along the border of the two countries using graphic symbology to show the layout of ground forces, air forces, and the location of the eight missile launchers. Shortly after the strike vehicles arrive in the area, MITCH identifies five tanks crossing the border. The pilot of the first vehicle immediately targets and destroys all five tanks. At the same time, MITCH alerts the pilots of the second and third vehicles that it has detected rocket ignition of five of the eight "Tehran" missiles. The system instantly provides targeting information to the strike vehicles' onboard systems and the missiles are destroyed two seconds after the missile engines fire.

Notes

[1] Department of the Army, *Army Focus 94, Force XXI*, September 1994, 39.

[2] Toshinori Munakata, (1994), "Commercial and Industrial AI," *Association for Computing Machinery. Communications of the ACM* [Online], 23, Available: ProQuest Online [1996, January 27]; Pattie Maes, (1994), "Agents That Reduce Work and Information Overload," *Communications of the ACM* [Online], 30, Available: ProQuest Online [1996, January 27]

[3] Bill Gertz, "The Air Force and Missile Defense," *Air Force Magazine* 79, no. 2, (February 1996): 73.

Chapter 5

Investigation Recommendations

Does the United States (US) want to succeed in the battlespace of 2025? Is it in America's best interest to field the capability vividly portrayed in the last two chapters? The answer must certainly be an *emphatic yes*! National survival will increasingly depend on getting the right information to the right decision maker at the right time. MITCH offers all three and provides the cornerstone for revolutionary comprehension of the global battlespace.

Certainly, America's steps will be challenged all along the way. Both enemies and friends are sharing in the technological explosion of this age. They, too, aspire to acquire systems that provide "global awareness" and "information dominance"—systems that threaten to be superior to our own. In just one example, Andrew Krepinevich, Jr., notes that Russia is energetically developing concepts for "Reconnaissance Strike Complexes." These complexes strive to dramatically reduce Russian decision loops by electronically linking sensors, target acquirers, and weapons.[1] The US cannot allow this to go unchallenged. Only a focused strategic plan will put us in the driver's seat—a plan that brings MITCH on-line as soon as possible. This final chapter lays the ground work for that plan and suggests four areas for further investigation: technology considerations, cultural considerations, acquisition methodology, and acquisition management.

Technology Considerations

Maj Gen Garrison Rapmund, USA, Retired, foreshadowed perhaps the most significant aspect of any strategic plan, "keep the vision." After receiving a briefing capturing the essence of MITCH, the general said little about technologies, but a lot about the analogy of the "Man in the Chair." He noted that Washington, D.C., desperately needs a clear vision of the system end-state. The "Man in the Chair," he noted, provides one. It provides a vision that allows decision makers to evaluate an infinite stream of "interesting" technologies, recognize the ones that advance the concept of MITCH, and fund them.[2] Keep the vision. Insist on "major league" competencies in global awareness and information dominance. Do not let skepticism rule out what may truly be possible in 2025.

The general's call to adhere to "the vision" becomes increasingly significant once one realizes the commercial sector will develop the major share of MITCH's processing, space, and AI technologies. Systems that sense and evaluate their environment with human precision are potentially very lucrative products. The profit motive, and the fact that these systems bring tremendous efficiencies to nearly every industry, will drive overwhelming commercial motivation to push the state of the art. In light of this impetus, a clear government vision of MITCH provides the framework for recognition and application of commercial advances.

Commercial Advances

Consider today's commercial advances. Current estimates predict that desktop computers in 2020 will be "as powerful as all the computers in Silicon Valley today."[3] By the year 2000, the 66-satellite Iridium system promises to provide worldwide portable telephone service. Shortly thereafter, the 840 small satellite Teledesic system promises to provide near worldwide transmission of video and sophisticated digital information.[4] In remote sensing, commercial planners look to soon deploy small, multispectral and optical imaging systems with relatively high resolutions.

Commercial projects like RAND Corporation's Holographic Neural Technology and Taiwan's neural-network IC Alliance are aggressively addressing neural network parallel processing. Taiwan's neural-

network IC Alliance is currently developing reasonably priced neural-network integrated circuit chips for commercial use.[5]

Companies like CYC in Austin, Texas, promise to lead the way to software agents with the ability to take individual patterns and determine broader concepts.[6] By 2025, these software agents may well teach themselves and evolve new and even more effective agents.[7] The list goes on. But what does this commercial development mean for MITCH? It means the United States will not have to pursue expensive development and acquisition programs for many of MITCH's key technologies. Many technologies will be available off-the-shelf at a fraction of the cost of a government procurement program. The US will, however, have to establish a critical framework from which to recognize and apply commercial advances. Americans must work hard at "knowing it when they see it." MITCH, as a vision, helps meet that challenge.

Areas Requiring Military Emphasis

Although commercial involvement will drive nearly every technology required by MITCH, there are two areas that merit DOD emphasis—network security and applications programming.

The sheer size of MITCH's network and its myriad of users produces a security challenge that probably exceeds commercial requirements. Unquestionably and absolutely, unauthorized users must not gain access to MITCH. The security, however, of an architecture spread across earth and sky is inherently at risk. The risk is compounded by the need to grant users access to the system at all levels of war. Today's most secure procedures—retinal scans, voice templates, fingerprints, and deoxyribonucleic acid matching—may not be enough to limit the risk of enemy intrusion. New and revolutionary techniques must be developed. In addition to protecting the system from "hackers," MITCH must also control the access of authorized users. Recognizing a user's authorized security clearance and restricting access to the IntelSpace accordingly is a huge challenge. As data is fused into information and possibly knowledge, where and how does the IntelSpace draw the line? It is a question that the architects of MITCH must address. Their solution must delicately balance "need to know" considerations with the user's requirement for complete answers.

A second area requiring vigorous military development is the area of applications programming. As alluded to in earlier sections, the "long pole" to MITCH is not whether technologies will exist, but in how the

technologies are applied to the enormous task that MITCH faces. Intelligent pattern recognition at a global level requires conventional processing, AI, and agent applications tailored to the complex subtleties of interpreting world events. Programming and initializing MITCH will require extensive efforts from developers and users. It will be a long process that begins with solutions to small, well-defined problems and ends with a system capable of interpreting large, ill-defined scenarios. It is a process that must start now.

Cultural Considerations

Time will prove the technological feasibility of MITCH. However, another issue is equally as important in determining MITCH's success—cultural acceptance. For years the military has "stovepiped" intelligence data in separate organizations. Imaging systems, for example, operate within a community much different than systems dedicated to signals collection. As a result, fusion of data seldom occurs. When it does, it is only through rare, deliberate efforts. This structure, motivated by cold war security imperatives to compartmentalize US technology, must radically change if MITCH is to reach its full potential. Department of defense and other US agencies must move to integrate their collection, processing, and dissemination systems. Decision makers and the supporting intelligence community must begin to think in terms of fused end-products, not in terms of independent sensor types. This cultural shift will take time but must occur.

In addition to breaking down "stovepipes," Americans must become less skeptical about using automated information systems as decision-aiding tools. As Brig Gen William Harmon notes, battlefield commanders must first trust automated intelligence before they will use or even build it.[8] This trust can only be developed over time and will evolve with each incremental step in technology—a result that has strong implications for the way the US should go about acquiring MITCH.

Acquisition Methodology

Considering both technology and cultural factors, an acquisition strategy for MITCH should follow two principles. First, the US should leverage commercial advances to the greatest extent possible. Second, from

now until the year 2025, the military should build prototypes that, with each iteration, move closer and closer to the MITCH concept.

This acquisition strategy gives MITCH's architects the flexibility to test promising technologies as they emerge. It allows them to experiment before locking into the final system architecture. Since prototypes are relatively inexpensive, the costs associated with shifting to the next generation of products are more affordable. As a result, the development community is less likely to become mired in old technology for budget reasons. Another advantage to prototypes is their reduced scope of operation. This lets MITCH's developers work system problems on a small scale before tackling problems for a large, complex system. In the end, prototypes and the flexibility to stay with the tide of commercial developments will improve the final configurations of MITCH.

In addition to helping steer technology, prototyping will also help transform the user culture. With each prototype delivered, users will grow increasingly accustomed to working with automated information systems. They will thoroughly train with what MITCH offers. They will find ways to use MITCH in an ever widening range of day-to-day operations. When the full version of MITCH is delivered in 2025, it will be to users that have already grown to trust the system.

Acquisition Management

Managing the acquisition of MITCH presents a significant challenge. Without proper order, the methodology discussed might easily evolve into a set of disjointed technology efforts. As a result, someone must orchestrate MITCH's acquisition so that the end product is a single, integrated whole. The job is too big for a single program office. Instead, it is a job for a larger organization, similar in style to the old Strategic Defense Initiative Office (SDIO). The SDIO skillfully guided a plethora of technologies toward the vision of a missile defense shield. It loosely guided technology development while holding tight to a vision. A similar organization must do the same for MITCH. This organization must carefully balance centralized control of MITCH, the vision, with decentralized control of the experiments and technologies that will one day achieve it. In addition, the organization must foster cooperation of the commercial and government sectors.

Concept Development from Here

The first task of the managing organization must be to further clarify and refine what MITCH is as a concept. The nation's finest minds must pick up where this white paper leaves off. During the concept development phase, government think tanks, contractors, and military users should jointly identify what is required of MITCH. What must it do? How must it do it? Who must it do it for? In essence, the all-important system vision must be expanded in more detail. This phase will especially seek to identify required technologies that will remain underdeveloped in the commercial sector. Commercial interest in some areas can be encouraged through government funding for research and development. The remaining technologies, however, should be assigned to defense laboratories or contractors for early concept work. In addition to conceptualizing the elements of MITCH, the US must also develop a picture of the supporting systems required to make MITCH a reality. Spacelift is one good example. This and other partners in the total system must be considered as early as possible.

Once MITCH has matured as a concept, developers should begin building the pieces. Their actions must be guided by development standards. These standards will define the interfaces and protocols that plug users and sensors into MITCH through any communications medium. They are the key tools in the managing organization's ability to synchronize parallel developments while still permitting design flexibility.

SenseNet Evolution

Over the next 30 years, American on-orbit constellations will see three more generations of surveillance and reconnaissance satellites—the result of expected satellite lifetimes. In replenishing these constellations, the US should move away from today's large satellites to a distributed network of numerous smallsats. Technologies fundamental to the SenseNet must find their way on-orbit with each successive satellite generation. One strategy to that end is to drive satellite size down while holding sensor performances at current levels.

IntelSpace Development

Just as today's satellite constellations presage the SenseNet, so today's systems for intelligence processing and dissemination presage the IntelSpace of 2025. Appendix A lists no fewer than eight such systems and MITCH's architects would be wise to heed the corporate lessons learned.

Drawing on these lessons and armed with a clear vision of MITCH, developers must focus first on AI core technologies. Artificial intelligence (AI) is the engine that drives the most critical functions of the IntelSpace. Tailoring it to suit MITCH will require extensive applications programming, an effort that calls for a significant cadre of trained programmers very early in the development. As alluded to in previous sections, prototypes will be the tool used by IntelSpace programmers to incrementally grow capability. Prototypes must first demonstrate competence in fundamentals before progressing to broader challenges. For example, the ability to reliably recognize the pattern of a tank is basic to the more challenging task of concluding an invasion is in progress. Measuring such performance will require sophisticated and detailed test cases. To provide continuity from prototype through operational system, the US must train personnel for early development of these complex test cases.

Eventually, AI and more conventional processing programs will mature to the point where system prototypes can begin exercises with live data collection. These system prototypes will connect AI with the commercial sector's best communications, mass storage media, and processors. Overlaying it all will be the fruit of concerted American efforts to provide reliable network security. The most successful prototypes should be offered to small cross sections of the operational community for trial periods. Feedback from these users will ultimately strengthen MITCH's human-machine interface.

Supporting Acquisitions

The success of MITCH depends on and is influenced by other supporting acquisitions. Two prominent examples are user devices and spacelift.

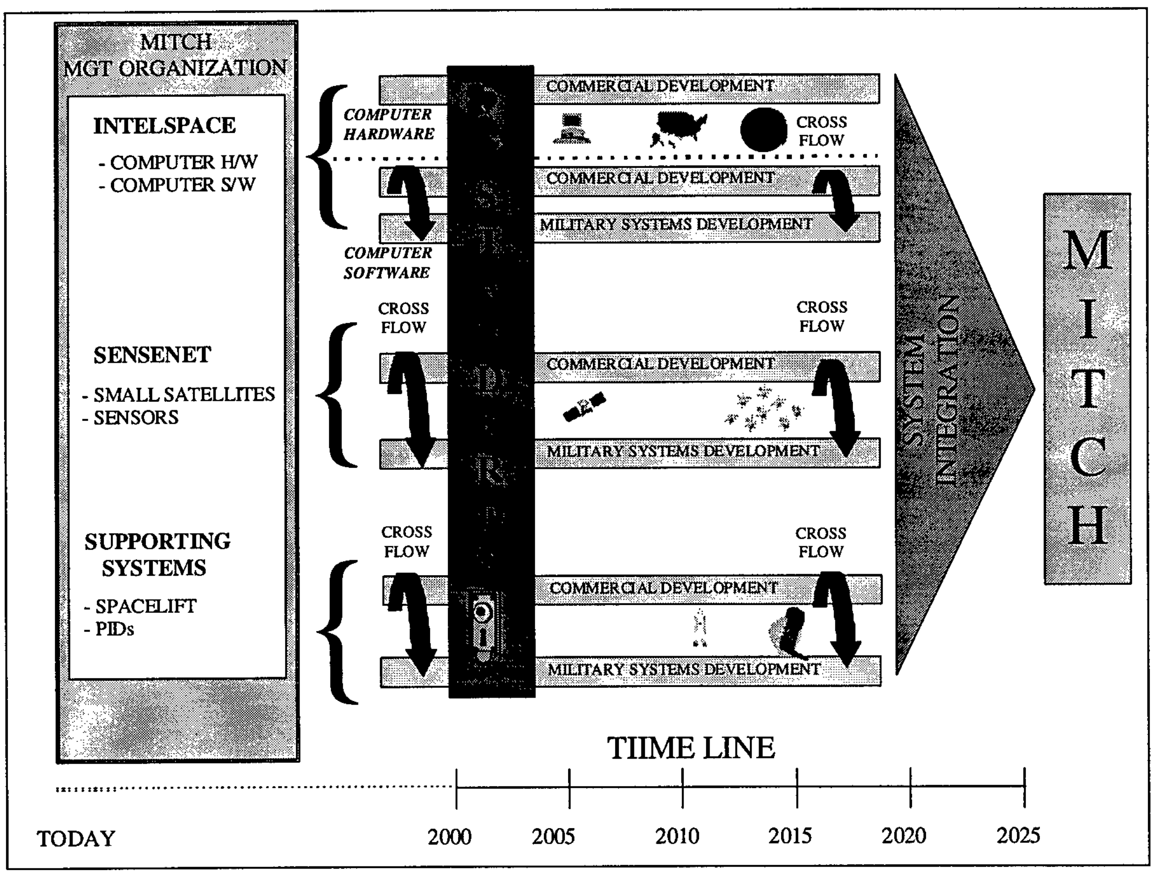
Outside MITCH's system boundaries, user devices will drive the form and content of the presentation of MITCH's information. How users want this information displayed on their personal interface devices and other input/output systems will influence the IntelSpace's final design. Standardized interface specifications will minimize design changes that might result from unnecessary incompatibilities between users and

MITCH. Not all design changes are bad, however. Developers should aspire to remain responsive to user requirements and "desirements" throughout the acquisition process.

The spacelift architecture discussed in the ***2025*** paper "Spacelift for 2025" is a linchpin to orbiting the hundreds of SENSATs required to complete the SenseNet. Clearly, the design of SENSATs will be influenced by the evolution of that launch system. This traditional link between launch vehicle and payload warrants close attention and detailed coordination.

Acquisition Summary

The following illustration highlights the major points of the proposed acquisition strategy for MITCH (fig. 5-1).



Source: Clipart from Microsoft Clipart Gallery © 1995 with courtesy from Microsoft.

Figure 5-1. Acquisition Strategy.

end. Second, the acquisition strategy allows the IntelSpace, SenseNet, and other supporting systems to ride on the crest of commercial developments. This allows scarce military and government developers to focus on computer software for AI applications and network security. Finally, this acquisition strategy does not culminate in a single, all encompassing delivery. Instead, the road of capabilities is incrementally traveled. System integration is deferred until prototypes and smaller operational systems have proven "Man in the Chair" concepts.

Conclusion

> Intelligence support of the combat command and control (C^2) function is a key ingredient in creating and maintaining a decisive advantage in battle—knowing not only what the enemy is doing now, but also anticipating what he is likely to do next. Providing that information to the right people at the right time is the challenge Air Force Intelligence faces in designing C^3I systems and organizations.[9]

Maj Gen Schuyler Bissell, the author of the above quote, sees future warfare for what it is. He is talking about global awareness and information dominance. He is asking for a set of required capabilities that MITCH and the "Man in the Chair" concept can provide by the year 2025.

Will the US rise to meet the challenges of 2025? Will we have unrivaled comprehension of the global battlespace? Will it be the US or our adversaries that most effectively *"follow the enemy situation in order to decide in battle?"*[10] The vision of MITCH, proposed herein, provides the answer. The US must act immediately to preserve its competitive edge—and the freedom it protects.

Notes

[1] Andrew F. Krepinevich, "The Military-Technical Revolution: A Preliminary Assessment," in *War Theory*, ed. Air Command and Staff College, War Theory and Campaign Studies Department (Maxwell AFB, Ala.: Academic Year 1996): 166.

[2] Maj Gen Garrison Rapmund, USA, Retired, assessor comment to ***2025*** white paper briefing, "The 'Man in the Chair'—Cornerstone of Global Battlespace Dominance," 7 February 1996.

[3] David A. Patterson, "Microprocessors in 2020," *Scientific American* 273, no. 3 (September 1995): 51.

[4] John L. Petersen, *The Road to 2025: Profiles for the Future* (Corte Madera, Calif.: Waite Group Press, 1994), 193.

Notes

[5] Charlene Huang, (1995), "Taiwan to develop mass market neural-network ICs," *Electronics* [Online], 1. Available: ProQuest Online [1996, January 27].

[6] Douglas B. Lenat, "Artificial Intelligence," *Scientific American* 273, no. 3 (September 1995): 62.

[7] Herbert Kaufman, (1994), "The Emergent Kingdom: Machines that think like people," *The Futurist* [Online], 20. Available: ProQuest Online [1996, January 27].

[8] Brig Gen William E. Harmon, USA, and Col Richard Webb, USA, "Evolution and Progress: The All Source Analysis System/Enemy Situation Correlation Element," *SIGNAL* 42, no. 4 (December 1987): 26.

[9] Maj Gen Schuyler Bissell, USAF, and Lt Col Daniel G. Kniola, USAF, "Intelligence for Warfighting," *SIGNAL* 41, no. 1 (September 1986): 48.

[10] Sun Tzu, *The Art of War*, ed. and trans. Samuel B. Griffith (London: Oxford University Press, 1963), 140.

Appendix A

Sample Systems

This appendix lists and briefly describes current and near-term systems used for intelligence gathering, processing, and dissemination. This list is not all inclusive.

CURRENT SYSTEMS[1]

1. Contingency Theater Automated Planning System (CTAPS) for Air Tasking Order (ATO) preparation and dissemination

2. Constant Source—an automatic associator receiving threat data from national and theater systems via the Tactics and Related Applications (TRAP) broadcast and providing an Electronic Order of Battle

3. Department of Defense Intelligence Information System—supporting "timely" preparation and presentation of intelligence information to military commanders and national-level decision makers

4. Joint Deployable Intelligence Support System (JDISS)—supporting imagery dissemination and providing a backbone for secondary imagery

5. Regional Operations Control Center/Airborne Warning and Control System (ROCC/AWACS) Digital Information Link (TADIL) —providing real-time surveillance and battle management information

6. Joint Situational Awareness System (JSAS)—providing some multi-source fusion products for a limited set of users

FUTURE SYSTEMS[2]

1. Joint Worldwide Intelligence Communications System (JWICS) —providing secure, high-speed multimedia network connectivity between and among all levels from National Agencies and Commands to deployed forces

2. Joint Service Imagery Processing System (JSIPS)—a modular, deployable imagery exploitation system with the capability to receive, process, and exploit near real-time

inputs from national and tactical assets and then disseminate imagery and message products to commanders at all levels

Notes

[1] HQ ACC/SCX, *C4I Systems Guide,* Langley AFB, Va., 1994.
[2] Ibid.

Appendix B

CLARK Small-Satellite Initiative Technology Areas

This appendix lists 36 technology areas advanced through the CLARK small-satellite initiative.[1]

TECHNOLOGY SYNOPSIS CONTENTS

Electrical Power Subsystem

1. Non-Dissipative Shunt Control
2. S/W Based Battery Charge Control
3. Amorphous Silicon
4. Multi-Junction GaAs Photovoltaics
5. Thin Cell GaAs Photovoltaics
6. Astro Edge Composite Concentrator Solar Array
7. Solid State Remote Power Controllers for Power Distribution
8. NiH2 SPV Batteries

Command and Data Handling

9. Open Architecture Integrated Avionics
10. 32-bit Processor (RHC3000)
11. 3-D Cube Mass Memory Packaging
12. Plastic Parts/Parts Stacking
13. Radiation Hardened FPGAs
14. 16 Mb DRAM Memory Chips
15. Multi-Functional Serial I/O Bus Memory Mapped to CPU
16. Composite Avionics Housing

Attitude Determination and Control Subsystem

17. Mini Star Tracker
18. Fine Horizon Sensor
19. Low Cost Coarse Sun Sensor
20. Star Tracker Attitude Rate Measurement
21. HRG Gyro
22. GPS Attitude Determination
23. Low Cost Reaction Wheels

Structures

24. Integrated, Multi-Functional Composite Shell
25. Thermally Conductive Composites
26. Composite Post-Potted Inserts
27. Self-Aligning Bond-On Nutplates

Mechanisms

28. Shape Memory Solar Array Gimbal
29. Shape Memory Retention & Release Device
30. Composite Mechanism Housing
31. Frictionless Flexure Solar Array Hinge

Instruments

32. Miniaturized MAPS Instrument (micro-MAPS)
33. Onboard Feature Identification
34. Image Data Compression
35. Room Temperature X-Ray Detectors
36. 3-D Imaging of Atmospheric Trace Gases

Notes

[1] CTA Incorporated (No date). *Clark Technology Synopses*, on-line internet, 12 February 1996, available from HTTP: http://www.futron.com/clark/clark.clark.html.

Appendix C

MITCH Tasks

The Air Force Institute of Technology (AFIT) is conducting an operational analysis in support of the 2025 study. Accordingly, they are scoring each ***2025*** white paper for its expected performance against a hierarchy of future tasks. This appendix identifies the tasks appropriate to MITCH and estimates to what level MITCH will perform them.

AFIT's hierarchy of tasks (fig. C-1) stems from the single operational goal of "Air and Space Superiority." This goal is divided into three distinct mission areas: "Awareness," "Reach," and "Power." MITCH falls squarely within the scope of "Awareness."

The mission of "Awareness" is further broken out into the three principle tasks of "Detect," "Understand," and "Direct." Several subtasks and numerous force qualities are subordinate to each of these tasks (fig. C-2). For example, "Understand" divides into the subtasks of "Identify" and "Integrate." The subtask of "Identify" is, in turn, evaluated against the force qualities of "Accurate," "Timely," and "Traceable."

The following tables evaluate how well MITCH satisfies the hierarchy of tasks *at the force quality level*. One table is provided for each of the three tasks supporting the "Awareness" mission. The first three columns of every table identify the *tasks*, *subtasks*, and *force qualities*. The fourth and fifth columns carry the *measurands* and *range*, as defined by AFIT, for every force quality. The sixth column in each table evaluates the *system performance* expected for all force qualities. The evaluations are drawn from explicit discussions in the body of this paper or by reasonable extrapolations of MITCH concepts. The seventh and final column refers the reader to a note that rationalizes the scores given in the system performance column.

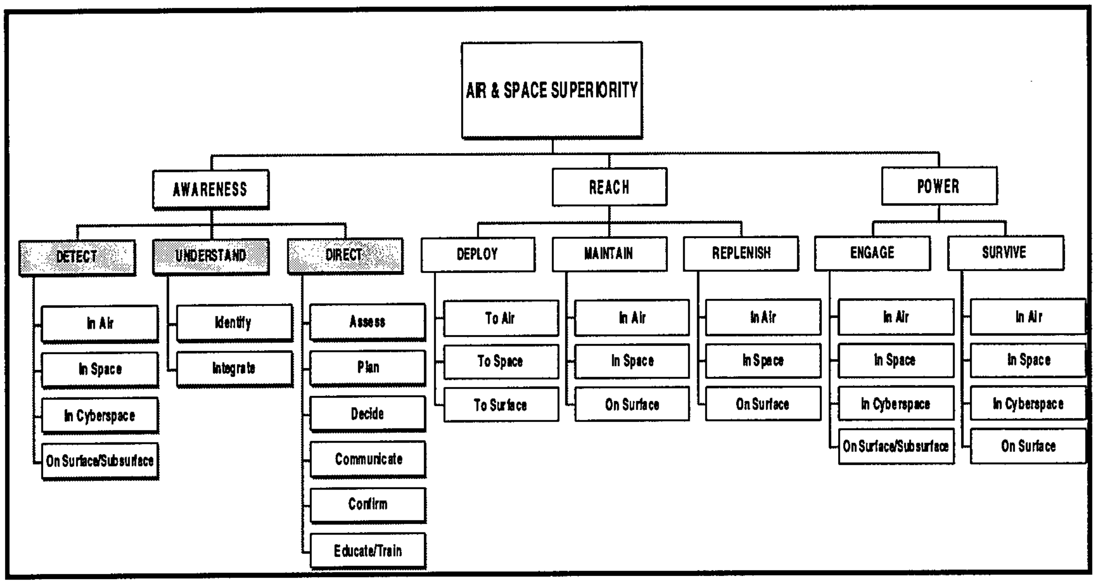


Figure C-1. *2025* Operational Analysis Structure.

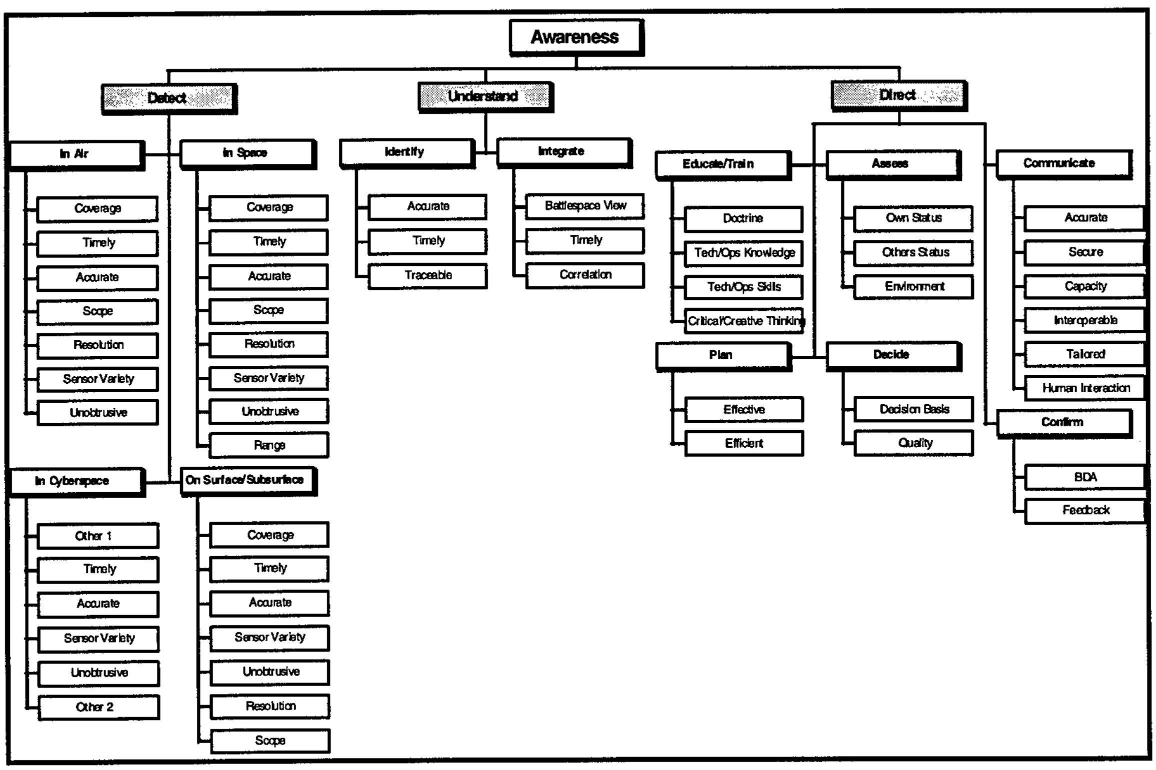


Figure C-2. Force Qualities Supporting the Awareness Mission.

Table 1

Analysis: The "Detect" Task

Task	Subtask	Force Quality	Measurand	Range	System Performance	Note
Detect	Air, Space, Surface/ Subsurface, or Infosphere	Sensor Variety	Spectral Completeness	0 to 5 Sensor Types	Probably More Than 5	1.
		Coverage	% of Earth	0 to 100%	100%	2.
		Timeliness	Revisit Time	0 to 24 Hours	0 (Continuous)	3.
		Unobtrusiveness	Enemy Knowledge of System	Full to None	Near full knowledge of space presence. Less to none for other sensor types.	4.
		Accuracy	Meters	0 to Infinite	Sub-meter, if required.	5.
		Scope	Day/Night Weather	0 to 100%	High (90+%)	6.
		Resolution	% Target Completeness	0 to 100%	100%	7.
		Range	Range	0 to 20 Astronomical Units	Near zero	8.

1. **Sensor Variety**. MITCH provides a spectrally complete set of sensors in space, and it accepts inputs from all sensors in the air, on the ground, or in the infosphere. It is almost certain this range of sensors will exceed the maximum score of five. Thus, as an intelligence fusion system, it should get full marks in all sensor categories.

2. **Coverage**. MITCH maintains two satellites of every sensor type over every spot on the globe. In addition, it receives inputs from other air, land, sea, and human collectors.

3. **Timeliness**. Given instantaneous global coverage of the SenseNet, revisit time is always zero in surveillance mode. In reconnaissance mode (high resolution or high sensitivity), revisit time can be made zero (continuous) with appropriate allocation of resources.

4. **Unobtrusiveness**. While both survivability and resistance to deception/evasion are important force qualities, "unobtrusiveness" is but one approach to achieve them. MITCH scores high in both of these important qualities, even though the enemy may have perfect ("full") knowledge of our sensor's existence. It achieves survivability through proliferation of a distributed network of small spaceborne sensors whose survivability is derived from the inherent redundancy and dispersion of such a network. It undermines a target's ability to deceive or evade it through its persistence and spectral completeness.

5. **Accuracy**. MITCH offers the best geopositioning/location accuracy attainable. User accuracy requirements will be variable, but the tightest accuracy requirements are likely to approach one meter for some targeting systems. MITCH will be able to satisfy these requirements.

6. **Scope**. MITCH assures day/night and all-weather availability of sensor data to the 2025 war fighter by using an appropriate sensor mix on orbit. Synthetic Aperture Radar (SAR) imaging, for instance, will provide imagery at night or through clouds. Infrared (IR) sensors provide additional night imaging capability. Other types of sensors, such as COMINT collectors, are inherently available under almost all conditions.

7. **Resolution**. MITCH will provide high-resolution/high-sensitivity sensor collection—on demand, anywhere in the world, all the time.

8. **Range**. Range, measured in astronomical units (AU), is an irrelevant measure for systems surveying the earth's surface. This force quality applies only to planetary defense systems.

Table 2

Analysis: The "Understand" Task

Task	Subtask	Force Quality	Measurand	Range	System Performance	Note
Understand	Identify	Timeliness	Time	"Too Late" to "In Advance"	"Just in Time" to a "Little Ahead."	1.
		Accuracy	% correct IDs	0 to 100 %	High (90+%)	2.
		Traceability	% Traceable	0 to 100%	100%	3.
	Integrate	Timeliness	Time	"Too Late" to "In Advance"	"Just in Time" to a "Little Ahead."	4.
		Battlespace View	% Relevant Data	0 to 100%	High (90+%)	5.
		Correlation	% Historical Correlation	0 to 100%	High (80+%)	6.

1. **Identification Timeliness**. Identification of cues picked up by the SenseNet will be near instantaneous. This initial identification will be followed immediately by additional tasking to verify and corroborate data.

2. **Identification Accuracy**. MITCH will achieve a very high degree of identification accuracy through the use of high-resolution sensors and by tasking of multiple sensors and sensor types to corroborate initial cues detected by the SenseNet.

3. **Identification Traceability**. When MITCH "comes to a conclusion" or "offers an opinion" to a user, it clearly displays all the evidence (imagery, HUMINT reports, electronic intelligence inputs, etc.) that led MITCH to its conclusion. This allows users to evaluate the soundness of MITCH's hypotheses.

4. **Integration Timeliness**. MITCH integrates all sensory data and historical evidence necessary to promptly support answers to intelligence questions. It provides its conclusions to a user either "just in time" or slightly ahead of time, giving users time to react to the information.

5. **Battlespace View**. MITCH searches and analyzes all data in the national intelligence system relevant to a user's particular task. Through this reliable and comprehensive automatic data search, MITCH relieves users of the drudgery of analyzing "mountains" of raw sensory data, freeing them to plan, evaluate, and execute tasks.

6. **Integration Correlation.** MITCH accesses an extensive historical/archival database to answer user inquiries with existing information. Further, it will correlate archived and current sensor data to detect emerging patterns of behavior that should be highlighted or investigated further.

Table 3

Analysis: The "Direct" Task

Tasks	Subtasks	Force Qualities	Measurands	Range	System Performance	Notes
Direct	Assess	Own Force Status	% Forces Known	0 to 100%	High (90+%)	1.
		Others' Status	% Assets Known	0 to 100%	High (90+%)	2.
		Environment	% Known	0 to 100%	High (90+%)	3.
	Plan	Effectiveness	Consideration of Goals, Targets, and Priorities	0 to 100%	High (90+%)	4.
		Efficiency	Avoidance of Waste	0 to 100%	High (90+%)	5.
	Decide	Decision Basis	Consideration of Facts, Alternatives, and Uncertainty	0 to 100%	High (90+%)	6.
		Quality	Balance of Speed, Accuracy, and Risk	0 to 100%	High (90+%)	7.
	Communicate	Accuracy	% Accurate Data	0 to 100%	Near 100%	8.
		Security	% Data Protected	0 to 100%	Near 100%	9.
		Capacity	Gb/s	0 to 10,000	Max	10.
		Interoperability	% Relevant	0 to 100%	High (90+%)	11.
		Tailorability	% Tailored	0 to 100%	100%	12.
		Human Interaction	Method	None to Virtual Reality	Full Range	13.
	Confirm	Bomb Damage Assessment	% Accurate	0 to 100%	High (90+%)	14.
		Feedback	Time (Hours)	0 to 24	Near Real Time	15.
	Educate / Train	Doctrine	Level of Learning	Knowledge to Synthesis	Application	16.
		Tech/Ops Knowledge	Relevant Mil. Knowledge	0 to 100%	High (90+%)	17.
		Tech/Ops Skills	Relevant Mil. Skills	0 to 100%	Moderate (<50%)	18.
		Critical/Creative Thinking	Level of Learning	Knowledge to Synthesis	Synthesis	19.

1. **Assess Own Forces Status.** Since MITCH exercises global surveillance and reconnaissance, it is fully able to provide the status of friendly forces and resources. Further, it could be used to assess friendly capability relative to enemy capability, providing that assessment to commanders at all levels of operations.

2. **Assess Others' Asset Status.** This is MITCH's greatest strength—the ability to assess the enemy status, capability, and intent. MITCH achieves this through its extensive sensor network and historical data base.

3. **Assess Environment**. Since MITCH has access to all sensor data worldwide (including weather data, trafficability data, geodesy data, etc.), it could provide a fused picture of the battlefield environment for commanders at all levels of operations.

4. **Plan Effectiveness**. MITCH centralizes tasking of the SenseNet and all other US sensors according to user priorities. This will maximize the overall collection planning effectiveness for all US sensor systems. Further, MITCH provides a single repository of target information for all 2025 warriors to refer to in developing their plans. This maximizes the planning effectiveness of *users* at all levels of operations.

5. **Plan Efficiency**. MITCH's resource allocation decisions will balance collection requirements for intelligence problems at all levels of operations. This leads to extremely efficient resource management. Since it also frees humans from the mundane task of collection planning, users become more efficient in their other tasks, as well.

6. **Decision Basis**. MITCH's hypotheses, and hence user decision making, is well supported by robust historical archives and current collections. In addition, MITCH constantly allocates specific sensors against specific intelligence problems. Where requirements conflict, MITCH works to prioritize collections. It also makes decisions about who to "push" information to, and in what format that data should be presented. MITCH will make these decisions according to a holistic view achieved by virtue of its access to users and sensors at all levels.

7. **Decision Quality**. MITCH balances speed, accuracy, and risk in providing data to users. In addition, the quality of MITCH's decisions will be very high, improving over time with feedback.

8. **Communication Accuracy**. MITCH assumes the availability of reliable and redundant communication channels to its user interfaces. MITCH's nature as a distributed network ensures this.

9. **Communication Security**. Encryption schemes and protected downlinks will make SENSAT communications very secure. MITCH's IntelSpace is secured at the entry points via a robust mix of user authorization verification methods to limit the possibility of system breaches. It includes multilevel security practices to limit damage of any potential breaches.

10. **Communication Capacity**. The SenseNet contains state-of-the-art laser communications for satellite-to-satellite linking of sensor data. These will be among the best available in 2025. Considering just the raw sensor data rate puts SenseNet capacity at 5,000 Gb/s (40Gb/s per satellite x 125 satellites = 5,000 Gb/s). All other communications, including human-to-machine communications, will be supported via commercial or military systems external to MITCH. As a distributed architecture, MITCH will use whatever communication paths are available. Arguably, if MITCH passes data across all these paths, it will far exceed the maximum measurement of 10,000 Gb/s.

11. **Communication Interoperability**. MITCH will be interoperable with all communications media, supporting the key operational concept of Global "PlugIn Play."

12. **Communication Tailorability**. Tailorability is a central theme of MITCH and is reflected in the system's commitment to disseminate the "right product." This capability is provided through software user agents.

13. **Communication Human Interaction**. Human interaction is central to MITCH's capability. MITCH learns what users want and need through daily feedback. This interaction results in user-friendly products. MITCH can support whatever communications medium is fielded—from keyboards to virtual reality displays.

14. **Confirmation BDA.** Battle Damage Assessment (BDA) is a key component of "knowing the enemy situation," and MITCH is the obvious system of choice for this task. It has access to all sensor data and the ability to assess it. BDA accuracy should be near 100 percent.

15. **Confirmation Feedback.** Feedback is provided to users as requested through their agents. Any information a user needs about friendly or enemy performance is readily available in MITCH on a near-real-time basis.

16. **Educate/Train in Doctrine.** MITCH will provide a fairly robust doctrine training tool since it reflects the doctrine used to train it. As senior leaders formulate and input doctrinal approaches into MITCH, they will themselves be sharpened in the application of doctrine.

17. **Train in Technical/Ops Knowledge.** MITCH will be a rich training resource for military knowledge, since its databases will hold much of the relevant military information available. This data will be presentable to users in any desired format or context.

18. **Train in Technical/Ops Skills.** Use of MITCH will be an important skill for users at all levels of operations. The acquisition strategy inherently trains users to use MITCH and integrates MITCH into US operations through incremental prototyping.

19. **Educate in Critical/Creative Thinking.** MITCH will train its users in critical thinking by developing hypotheses new to the users that task the system. By its very nature, MITCH will "think" in a structured and critical way and will train users in the same way of thinking.

Bibliography

2025 Concept. No. 200059. "Automated & Integrated Intelligence Seamless Fusion & Correlation System." *2025* Concepts Database. (Maxwell AFB, Ala.: Air War College/*2025,* 1996).

Ackerman, Robert K. "When Words Fail, Data Base Themes Prevail." *SIGNAL* 50, no. 7 (March 1996): 51–53.

ACSC Technology Division and the War/Theater Level Studies Department. "The O-O-D-A Loop" Toolbook. Maxwell AFB, Ala.

AFP 200-18. *Target Intelligence Handbook Unclassified Targeting Principles*, vol. 1. 1 October 1990.

Asker, James R. "Space, Key to U.S. Defense." *Aviation Week & Space Technology* 138, no. 18 (3 May 1993): 51–53.

Bissell, Schuyler, Maj Gen, USAF, and Lt Col Daniel G. Kniola, USAF. "Intelligence for Warfighting." *SIGNAL* 41, no. 1 (September 1986): 48–51.

Boyd, John R. "A Discourse on Winning and Losing." Paper presented at Air University for CSAF's *2025* project, Maxwell AFB, Ala. 27 September 1995.

Braunberg, Andrew C. "Data Warehouses Migrate Toward World Wide Web." *SIGNAL* 50, no. 6 (February 1996): 35–37.

Brown, Carol E., James Coakley, and Mary Ellen Phillips. "Neural Networks: Nuts and Bolts." *Management Accounting (USA)* 76, no. 11 (May 1995): 54–55.

Campen, Alan D. contributing ed., *The First Information War*. Fairfax, Va.: AFCEA International Press, 1992.

Chan, Vincent W. S. "All-Optical Networks." *Scientific American* 273, no. 3 (September 1995): 56–59.

Clausewitz, Carl von. *On War*. Edited and translated by Michael Howard and Peter Paret. Princeton, N. J.: Princeton University Press, 1976.

Colodney, Maj Lori. "Getting Command and Control System Back into the Fight on the Digitized Battlefield." Fort Leavenworth, Kans., 17 December 1994.

Cortese, Amy with John Verity, Kathy Rebello, and Rob Hof. "The Software Revolution." *Business Week*, no. 3453 (4 December 1995): 78–90.

CTA Incorporated (No date). *Clark Technology Synopses* [Online]. Available HTTP: http://www.futron.com/clark/clark.clark.html [1996, February 12].

Da Silva Curiel, R. A. (No date). *Satellites in the making . . .* [Online]. Available HTTP: http://www.ee.surrey.ac.uk/CSER/UOSAT/SSHP/future.html [1996, February 12].

———. (No date). *The Small Satellite Home Page* [Online]. Available HTTP: http://www.ee.surrey.ac.uk/CSER/UOSAT/SSHP/sshp.html [1996, February 12].

Department of the Army. *Army Focus 94, Force XXI.* September 1994.

Dibbell, Julian. "The Race to Build Intelligent Machines." *Time* 147, no. 13 (25 March 1996): 56–58.

Gande, William. "Smallsats Come of Age?" *Ad Astra* 6, no. 6 (November/December 1994): 22.

Gertz, Bill. "The Air Force and Missile Defense." *Air Force Magazine* 79, no. 2, (February 1996): 72–74.

Harmon, Brig Gen William E., USA, and Col Richard Webb, USA. "Evolution and Progress: The All Source Analysis System/Enemy Situation Correlation Element." *SIGNAL* 42, no. 4 (December 1987): 25–30.

HQ ACC/SCX. *C^4I Systems Guide.* Langley AFB, Va., 1994.

Huang, Charlene. (1995). "Taiwan to develop mass market neural-network ICs." *Electronics* [Online], 1. Available: ProQuest Online [1996, January 27].

Kaufman, Herbert. (1994). "The Emergent Kingdom: Machines that think like people." *The Futurist* [Online], 20. Available: ProQuest Online [1996, January 27].

Kosko, Bart. *Fuzzy Thinking.* New York: Hyperion, 1993.

Krepinevich, Andrew F. "The Military-Technical Revolution: A Preliminary Assessment," in *War Theory.* ed. Air Command and Staff College, War Theory and Campaign Studies Department. (Maxwell AFB, Ala.: Academic Year 1996): 163–98.

Lawlor, Maryann. "Learning Computers Complement Teaching, Planning, Testing." *SIGNAL* 50, no. 7 (March 1996): 54–56.

Lenat, Douglas B. "Artificial Intelligence." *Scientific American*, no. 273 (September 1995): 62–64.

Levine, John R. and Carol Baroudi. *The Internet For Dummies.* 2d ed. Foster City, Calif.: IDG Books Worldwide, Inc., 1994.

Maes, Pattie. (1994). "Agents that Reduce Work and Information Overload." *Association for Computing Machinery. Communications of the ACM* [Online], 30. Available: ProQuest Online [1996, January 27].

McNeill, Daniel and Paul Freiberger. *Fuzzy Logic: The Revolutionary Computer Technology That is Changing Our World.* New York: Simon & Schuster, 1994.

Munakata, Toshinori. (1994). "Commercial and Industrial AI." *Association for Computing Machinery, Communications of the ACM* [Online], 23. Available: ProQuest Online [1996, January 27].

Negroponte, Nicholas. *Being Digital.* New York: Vintage Books, 1995.

Owens, Adm William A. "The Emerging System of Systems." *US Naval Proceedings* 121, May 1995 36–39.

Patterson, David A. "Microprocessors in 2020." *Scientific American* 273, no. 3 (September 1995): 48–51.

Petersen, John L. *The Road to 2015: Profiles of the Future.* Corte Madera, Calif.: Waite Group Press, 1994.

Robinson, Clarence A., Jr. "Holographic Storage Media Could Eclipse Optical Disks." *SIGNAL* 50, no. 6 (February 1996): 31–33.

———. "Powerful Battlefield Forces Exploit Space-Based Access." *SIGNAL* 50, no. 7 (March 1996): 33–35.

Scott, William B. "Russia Pitches Common Early Warning Network." *Aviation Week & Space Technology* 142, no. 2 (9 January 1995): 46–47.

SPACECAST 2020. Air University. "Leveraging the Infosphere: Surveillance and Reconnaissance in 2020." AU study. 22 June 1994.

Sun Tzu. *The Art of War.* ed. and trans. Samuel B. Griffith. London: Oxford University Press, 1963.

Thompson, Suzanne J. (No date). *Mass Storage Technologies* [Online]. Available HTTP: http//www.nml.org/publications/NML_TR/task4_final/9_mass_storage.html [14 Feb 96].

Toffler, Alvin and Heidi. *War and Anti-War.* New York: Warner Books Inc., 1993.

USAF Scientific Advisory Board. *New World Vistas: Air and Space Power for the 21st Century,* Summary Volume. Washington, D.C.: USAF Scientific Advisory Board, 15 December 1995.

Van Creveld, Martin. *The Transformation of War.* New York: The Free Press, 1991.

Verity, John. "Meet Java, the Invisible Computer." *Business Week* 3452, no. 1 (4 December 1995): 82–83.

Widrow, Bernard, David E. Rumelhart, and Michael A. Lehr. "Neural Networks: Applications in Industry, Business and Science." *Communications of the ACM* 37, no. 3 (March 1994): 93–105.

Wright, Robert. "Can Machines Think?" Time 147, no. 13 (25 March 1996): 50–56.